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NAVY TRAINING LANDS SUSTAINABILITY: INITIATION DECISION REPORT

by
Naval Facilities Engineering Service Center, ESC411

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14. ABSTRACT

This effort documents a comprehensive DoD strategy for environmental RDT&E investments. It is difficult to assess the future success of current investments in relation to current and projected Navy problems. It was concluded, however, that investments that assist in transition of those technologies in the early stage of development to individual sites will increase the likelihood of success. Improved capabilities are needed in the areas of perchlorate, munition constituents toxicity data for risk assessment, coral reef assessments, training impact quantification, munition constituents field detection, and monitoring and mitigating releases from ranges. Advancing technologies in these areas will support the readiness of the warfighter and Navy Ranges by reducing compliance burdens, costs to programs, future regulatory constraints, and improved methods for impact avoidance and range management.

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TES/NEPA:	Jerry Olen
Munitions Constituents/Range Residue:	Jeff Karrh
Perchlorate:	Bryan Harre
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Risk Assessment:	Ruth Owens
GIS:	Mary Canfield
Noise:	Dr. Norman Helgeson/Dan Goodman
Air Pollution:	Dr. Norman Helgeson

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Leslie A. Karr
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EXECUTIVE SUMMARY

The Navy is actively engaged in a Training Lands Sustainability program to identify, characterize, and define potential sustainability issues on both land- and sea-based ranges and operating areas (OPAREAs). The primary range management program is the Tactical Training Theater Assessment Planning Program (TAP). TAP consists of an overall strategic plan and five major functional components:

- Strategic Plan
- Range Complex Management Plans (RCMPs)
- Environmental Planning Documentation (National Environmental Policy Act [NEPA])
- Marine Species Density Data (MSDD) for at-sea ranges
- Operational Range Clearance (ORC)
- Range Sustainability Environmental Program Assessment (RSEPA)

The goal of this program is to ensure the availability of adequate training and research, development, testing and evaluation (RDT&E) test sites for current and future military operations that protect range resources, the environment, and the public. Technology opportunities can be integrated into the components of TAP using various strategies within the Department of the Navy (DON) as well as the Department of Defense (DoD).

The Naval Facilities Engineering Service Center (NFESC) is compiling information using DoD resources to identify Fleet user needs and define potential environmental opportunity areas which can be minimized through an integrated RDT&E investment strategy. The results of this effort are presented herein, known as an Initiation Decision Report (IDR). The IDR documents a process by which user requirements are gathered, stakeholder networking is pursued, and a technology assessment is performed. A gap analysis is performed which compares requirements against available technology to determine shortfalls. Recommendations for RDT&E are proposed to fill the technology gaps.

This effort documents a comprehensive DoD strategy for environmental RDT&E investments. It is difficult to assess the future success of current investments in relation to current and projected Navy problems. It was concluded, however, that investments that assist in transition of those technologies in the early stage of development to individual sites will increase the likelihood of success. Improved capabilities are needed in the areas of perchlorate, munition constituents toxicity data for risk assessment, coral reef assessments, training impact quantification, munition constituents field detection, and monitoring and mitigating releases from ranges. Advancing technologies in these areas will support the readiness of the warfighter and Navy Ranges by reducing compliance burdens, costs to programs, future regulatory constraints, and improved methods for impact avoidance and range management.

The **Environmental Planning Documentation** for the TAP Range Complexes is being initiated upon completion of the RCMPs. RCMPs will establish baseline and proposed action

and alternatives for the **NEPA/Executive Order (E.O.) 12114 Documentation**. Currently, no NEPA/E.O. 12114 documentation has been completed for the TAP range complexes. It is expected that once the NEPA/E.O. 12114 documentation is in progress, new RDT&E investment opportunities will be identified to reduce compliance burdens, reduce impacts, and support mitigation and monitoring requirements. It will be important for the Chief of Naval Operations (CNO), Fleet, and Range Complex managers to have a process to identify, document, and input these environmental investment opportunities into an overall integrated strategy.

The number of environmental laws has grown exponentially over the last century. This trend is not expected to change. The public will continue to apply these laws to new areas as other problems/issues are corrected. Being to able to adequately characterize what is happening on the ranges will be essential to maintain the flexibility necessary to conduct RDT&E and training operations. New technologies are also necessary to prove the effectiveness of mitigation measures that are required as part of the environmental planning process. This will help ensure that more stringent mitigation is not unnecessarily imposed on the testing and operations communities in the future.

Threatened and Endangered Species (TES) play a significant role on training lands, as the DoD has the highest density of TES (8.4/million acres) with respect to other national lands (1.54 for National Park Service). The Navy has a comprehensive Integrated Natural Resources Management Plan (INRMP) program to ensure compliance, but there are still many unknowns about the effects of training upon TES. It is difficult to have a single technology to quantify, for example, the impacts that noise or munitions constituents have on birds, reptiles, or fish as a whole, let alone for each species on any given installation. Animal landscape modeling may provide focus as to which species and which stressor to look at more closely.

Within the **Protected Marine Resources** arena, the ability to characterize, assess, and monitor underwater benthic communities associated with DoD sites or activities is required to document compliance with promulgated national policy and to ensure that DoD operations do not lead to natural resource degradation, particularly with respect to coral reefs. While there are some current efforts looking at coral reef assessment, it is not clear how they will transition to the Navy and whether they will solve all of the evolving issues. This needs to be clarified to ensure adequate protection of these resources. Marine mammal issues are heavily invested in under a comprehensive Office of Naval Research (ONR) program, and research will continue to seek solutions, especially with respect to the effect of sonar on whales.

Munitions Constituents (MCs) play a significant role in compliance issues when they migrate off-range, are transported into water bodies, or are transferred to the biota living at or near a site. The following technology gaps have been identified that will help fill these gaps: (1) the development and documentation of workable management solutions for migration of MCs off-range; (2) the prioritization of MCs into those most likely to occur on Navy/USMC ranges, and their toxicity; (3) the investigation of additional technologies for the treatment of perchlorate-contaminated drinking water; and (4) the development of a Best Management Practices manual for operational ranges describing control procedures, available technologies, and other issues concerning MCs. It is anticipated that as the RSEPA process is implemented, new areas of concern and technology gaps will be identified that will benefit from technology enhancements.

The Navy and Marine Corps need assistance and new methods for managing **Range Residue** from testing and training operations. Range residue consists of used target material, spent munitions, ordnance fragments, general scrap and debris (e.g., tires), and munition

constituents such as TNT and RDX at high concentrations. Range residue is periodically cleared from the target areas but there is no protocol as how to handle the residue.

Range residue is material that potentially poses an explosive hazard (MPPEH). Considerable time and effort is required to collect, process, demilitarize, and certify that the processed material is not MPPEH. Technology gaps include protocols for properly managing the MPPEH, processing optimization, guidance and instructions on how to efficiently and safely process range residue.

The range residue management cost to sustain operational ranges is considerable. For example, at Naval Weapons Station China Lake, the costs are $600/ton for MPPEH clearance and up to $200/ton for off-site disposal. At their current MPPEH generation rate of 400 tons/yr, the range residue clearance and removal costs are approximately $320,000 per year.

Technology gaps in the area of **Range Management/Risk Assessments** are similar to those associated with risk assessments under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, and tie in with munition constituents. Key gaps were identified regarding perchlorate, munitions constituent toxicity data, benchmarks for key organisms and sensitive habitats (such as marine mammals and coral reef systems), trophic transfer modeling/bioavailability, and assessing risk to endangered species. Significant work is being done by DoD to fill some of these gaps. However, there does not appear to be a coordinated effort to prioritize efforts or centrally capture the data as it is produced.

Range Management/Geographical Information Systems (GIS) display information in spatial relationships. Data points such as endangered species areas, unexploded ordnance (UXO), wetlands, facilities, targets, noise areas, vegetation types, land use, and other factors of installation management can be graphically represented on a map. Several different applications of GIS are being used in the Navy and Marine Corps – all designed with specific requirements to the installation. The diversity and uniqueness of each installation and the various environmental regulatory requirements make it difficult to have a single GIS application that fits all services or all installations or all departments of an installation. The existing knowledge base at the various installations is at different levels. Some use GIS applications extensively like NAVAIR at Pax River, and PACDIV, others are just beginning to explore the possibilities of GIS applications, while others have no GIS at all. Using a GIS to support range encroachment issues has been identified as a gap. This gap can be filled with existing technology through a cooperative effort, as there are numerous initiatives throughout the DoD dealing with encroachment issues. The Army has a significant modeling effort with GIS components through their Fort Future program that will encompass all areas of sustainability, with potential for Navy and Air Force usage.

Range management issues are diverse in nature, and include invasive species control on one end of the spectrum to undersea cables at the other end. It is recommended that seafloor cable disposition be investigated because new permit applications are requiring consideration of removing old cables before installing new cables. Regulators in Southern California have recently made this a high priority for new cable installation. The findings of this case may set a precedent for future cable permits.

Invasive species are site-specific and controlling them is usually costly and labor-intensive. Wetland species of concern, for example, include *Phragmites*. Technology input may reduce the cost of maintaining ranges.

Sources of **Air Pollution** that may affect air quality over or near Navy/Marine Corps test and training ranges are open-burning/open-detonation (OB/OD), aircraft engine emissions, vehicle engine emissions, dust (PM_{10}) generated by vehicular operations, emissions from

intentional burns (prescribed fire) to manage vegetation cover range and fire-fighting exercises, and sea-borne vessel operations. The Clean Air Act (CAA) requires the Environmental Protection Agency (EPA) to establish standards and programs to protect air quality in the United States from military and other operations. "Conformity" has had its greatest impact on planned changes in operations at activities, but this rule can hamper planned upgrades or new training approaches in nonattainment range areas, as well.

$PM_{2.5}$ is the newest air pollutant to be regulated by the EPA, and states are now completing assessments of ambient $PM_{2.5}$ data for classification of regions (air districts) as nonattainment, attainment, or unclassifiable. $PM_{2.5}$ is different from PM_{10} in that it is produced as a direct emission from combustion devices or is formed in the atmosphere from NO_x and hydrocarbons present there (often of a size of less than 0.1 micron). $PM_{2.5}$ nonattainment areas are associated with large population and industrial centers – with the exception of some rural areas where smoke from wild-fires is a problem. Norfolk will not be affected by $PM_{2.5}$ nonattainment, but parts of Maryland up near Washington DC will be. Navy/Marine Corps operations in central California (e.g., Lemoore NAS) down through the Los Angeles area to San Diego will all be affected by the $PM_{2.5}$ nonattainment classification. $PM_{2.5}$ will not be a problem in desert areas (such as Twentynine Palms, CA) as most PM in those areas is dust-generated (PM_{10}), is of different character, and larger.

OB/OD takes place at both remote ranges and at ranges more proximate to base populations. How the emission of species from these operations can be controlled and how they react and are transformed in the atmosphere as they are transported from the OB/OD site to downwind locations is still being intensely investigated. Characterization of emissions from aircraft is one of the foremost environmental problems for the Navy. The EPA's Method 5 is no longer considered acceptable for measuring $PM_{2.5}$ emissions and the many complexities of PM formation and their reactions in engine exhaust plumes are being investigated. Improved measurement methods and emission factors are needed to update Navy aircraft contributions to pollutant inventories for both legacy and emerging aircraft platforms. Although aircraft emissions over test ranges do not currently appear to present an air quality problem, current evaluations do not address emissions from aircraft flights to and from ranges or other emissions related to aircraft operations at ranges. Although these emissions are considered to be relatively small and are not currently regulated, will the EPA allow this situation to remain unchanged? As analysis of air quality problems becomes more sophisticated, this may be an additional issue that the Navy will have to face. The contributions of sea-going Navy and Marine Corps vessels to range air quality issues is believed to be small, but this issue will also require continued evaluation. Emissions from fire-fighting exercises are an ongoing source of concern without adequate resolution.

Determination of the effect of any of the above issues on range air quality will depend, ultimately, upon the capability of the Navy to not only accurately characterize the strength and nature of its air emissions but to effectively model the impact of those sources on air quality in the related areas. Improved Navy air quality modeling capability will be required to address this need.

Although **Noise** is generated by a variety of military activities, that noise generated by the military's aircraft gas turbine (jet) engines in the atmosphere and by sonar operations in the ocean presents the Navy with two of its most pressing environmental problems. Ground vehicular operations can be significant sources of noise, but are more localized and more easily managed and reduced to acceptable levels. The noise generated by rotary wing aircraft can be extremely disruptive, but management of helicopter operational areas and the installation of

passive noise control measures usually reduces that noise to acceptable levels. However, the potential effect of helicopter operations on wildlife is still being evaluated. Reducing the noise from the increasingly powerful Navy jet engines is pushing the limits of what can be achieved, technologically, to reduce jet engine noise. There is no approved current plan for acceptably basing and operating the new aircraft that will be coming to the fleet within the next decade. Rather, several of the approaches being considered are: (a) incorporating new engine features on board the aircraft that would lessen the noise produced during flight, (b) measuring the magnitude and directivity of in-flight noise to assist in providing improved noise contours for proposed and operating air fields, (c) developing improved noise abatement devices for stationary testing of engines, and (d) development of noise generation and acoustical propagation models. Work is on-going in these areas, but technology gaps remain. The effect of the Navy's high-powered sonars on sea life is being investigated by NAVSEA and is not addressed here.

The final areas covered in this report include **Cultural Resources** and **Urban Encroachment.** Resources are being expended to a lesser extent than for other SROC issues by the Army and SERDP/ESTCP. Additional Navy gaps were not identified.

There has been a significant amount of activity in TAP over the past two years. Before finalizing an investment strategy that advances TAP goals, the key players must consider the technology opportunities and weigh them against overall program direction, new and proposed policy implementation, and compliance issues. Ample opportunities exist to contribute to filling these technology gaps by partnering with DoD stakeholders, initiating joint opportunities, and contributing input requirements in the RDT&E process.

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APPENDICES

ACRONYMS AND ABBREVIATIONS

ADS	Advanced Deployable System
AEDA	ammunition, explosives, and other dangerous articles
AFB	Air Force Base
AFP	amplifying fluorescent polymer
AICUZ	Air Installation Compatible Use Zone
AIS	Automated Information System
ARAMS	Army Risk Assessment Modeling System
ArcIMS	ESRI's Internet Mapping Service
ATTACC	Army Training and Testing Area Carrying Capacity
BAZE	Biologically Active Zone Enhancement
BRAC	Base Realignment and Closure
CAA	Clean Air Act
CADD	Computer-Aided Detector Design
CA DHS	California Department of Health Services
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERL	(U.S. Army) Construction Engineering Research Laboratory
CFFC	Commander, U.S. Fleet Forces Command
CFR	Code of Federal Regulations
CHPPM	(U.S. Army) Center for Health Promotion and Preventative Medicine
CLF	Combat Logistics Force
CMAQ	Community Multiscale Air Quality
CNEL	Community Noise Equivalent Level
CNO	Chief of Naval Operations
CPF	Commander, U.S. Pacific Fleet
CRCA	Coral Reef Conservation Act of 2000
CRE	Comprehensive Range Evaluation
CRTF	Coral Reef Task Force
CSM	Conceptual Site Model
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DAHA	1,1-diamino-3,3,5,7,7-hexaazidocyclothetraphosphazene
dB	decibel
dBA	A-weighted decibels
DNL	day-night average sound level
DNT	2,4-dinitrotoluene
DoD	Department of Defense
DoDD	Department of Defense Directive
DON	Department of the Navy

DPG	Defense Planning Guidance
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
DRMS	Defense Reutilization and Marketing Service
DTAG	Digital Whale Tag
DU	depleted uranium
DWEL	drinking water equivalent level
EA	Environmental Assessment
ECOUS	Environmental Consequences of Underwater Sound
EDQW	(DoD) Environmental Data Quality Workgroup
EEZ	Exclusive Economic Zone
EFHA	Essential Fish Habitat Assessment
EIMS	Environmental Information Management System
EIS	Environmental Impact Statement
E.O.	Executive Order
EOD	Explosive Ordnance Disposal
EPA	(U.S.) Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERC	explosives-related compound
ERDC	(U.S. Army Corps of Engineers) Engineer Research and Development Center
ERDC-EL	(U.S. Army Corps of Engineers) Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS
ESA	Endangered Species Act
ESH	Environmental Safety and Health
ESQD	Explosives Safety Quantity Distance
ESRI	Environmental Systems Research, Inc., Redlands, CA
ESS	Explosives Safety Siting
ESTCP	(DoD) Environmental Security Technology Certification Program
FAA	Federal Aviation Administration
FERM	Fire Ecology Range Management
FONSI	Finding of No Significant Impact
FUDS	Formerly Utilized Defense Site
FY	fiscal year
GAO	Government Accounting Office
GIFA	governing international fishing agreement
GIS	Geographical Information System
GIS-R	Geospatial Information System Repository
GRIT	GeoReadiness Integration Team
HAP	hazardous air pollutant
HIFLDS	Homeland Defense Foundation Layer Data Store
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

HW	hazardous waste
Hz	hertz
I2M	Integrated Installation Management
IDR	Initiation Decision Report
iNFADB	Internet Navy Facilities Assets Data Base
iNFADS	Internet Navy Facilities Assets Data Store
INRMP	Integrated Natural Resources Management Plan
IPL	Integrated Priority List
IRRS	Installation Readiness Reporting System
LEAM	(National Science Foundation) Land Use Evolution and Impact Assessment Model
LOAEL	lowest observed adverse effect level
LMRIS	Living Marine Resources Information System
LOD	low-order detonation
MAP	Munitions Action Plan
MBTA	Migratory Bird Treaty Act
MC	munitions constituent
MCAGCC	Marine Corps Air Ground Combat Center
MCAS	Marine Corps Air Station
MCBH	Marine Corps Base Hawaii
MCL	maximum contaminant level
MCO	Marine Corps Order
MEC	munitions and explosives of concern
mLEAM	military version of (National Science Foundation) Land Use Evolution and Impact Assessment Model
MMPA	Marine Mammal Protection Act
MMR	Military Munitions Rule
MPPEH	material potentially posing an explosive hazard
MRA	Marine Resource Assessment
MRL	method reporting limit
MS	mass spectrometry
MSDD	Marine Species Density Data
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSLS	Marine Species Literature Search
MSS	Marine Species Survey
MTBE	methyl *tertiary*-butyl ether
NAAQS	National Ambient Air Quality Standards
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAWCWPNS	(China Lake) Naval Air Warfare Center, Weapons Division
NEPA	National Environmental Policy Act
NFESC	Naval Facilities Engineering Service Center

NHPA	National Historic Preservation Act
NIMA	National Image and Mapping Association
NITC	NAVFAC Information Technology Center
nm	nautical miles
NMFS	National Marine Fisheries Service
NMRIS	Navy and Marine Corps Range Information System
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
NO_x	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRO	Navy Range Office
OB/OD	open burning/open detonation
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
OEBGD	Overseas Environmental Baseline Guidance Document
OEHHA	California EPA Office of Environmental Health Hazard Assessment
OESO	Ordnance Environmental Support Office
ONR	Office of Naval Research
OPAREA	Range and Operating Area
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	Operational Navy Instruction
ORC	Operational Range Clearance
ORSM	Operational Range Site Model
OSD	Office of Secretary of Defense
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PEP	propellants, explosives, and pyrotechnics
PHG	Public Health Goal
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
PMRF	Pacific Missile Range Facility
ppb	parts per billion
ppm	parts per million
PPBE	planning, programming, budgeting, and execution
PRB	permeable reactive barrier
PRBerm	Passive Reactive Berm
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QRP	qualified recycling program
QSM	(DoD) *Quality Systems Manual for Environmental Laboratories*

RAICUZ	Range Air Installation Compatible Use Zones
RCA	Range Condition Assessment
RCC	Range Commander's Council
RCMP	Range Complex Management Plan
RCRA	Resource Conservation and Recovery Act
R&D	research and development
RDT&E	research, development, testing and evaluation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
REVA	Range Environmental Vulnerability Assessment
Rf	retardation factor
RF	radiofrequency
RfD	reference dose
RHA	range holding area
RMS	root mean square
RRPC	range residue processing center
RRR	Risk Reduction Rule
R2R	Ranges-to-Readiness
RSG	Range Sustainability Group
RSEPA	Range Sustainability Environmental Program Assessment
RSim	Regional Simulation
RSIMS	Regional Shore Installation Management System
RSIP	Regional Shore Infrastructure Planning
RSSRA	Range-Specific Screening Risk Assessment
RSWG	(SERDP) Range Sustainability Work Group
SAP	Sampling and Analysis Plan
SAR	small arms range
SARA	Superfund Amendments and Reauthorization Act
SARNAM	Small Arms Range Noise Assessment Model
SCM	source characterization model
SCORE	Southern California Offshore Range
SCOS	Southern California Ozone Study
SDSS	Spatial Decision Support System
SDWA	Safe Drinking Water Act
SEA	Supplemental Environmental Assessment
SEAL	Sea, Air, and Land
SEL	sound exposure level
SEMP	SERDP Ecosystem Monitoring Program
SER	surface-enhanced Raman
SERDP	Strategic Environmental Research and Development Program
SOCAL	Southern California
SOFA	Status of Forces Agreement
SON	statement of need
SPAWAR	Space and Naval Warfare Systems Command
SPL	sound pressure level
SRM	Facilities Sustainment, Restoration and Modernization
SRO	Sustainable Range Oversight

SROC	Senior Readiness Oversight Council
SSC-SD	Space and Naval Warfare Systems Center, San Diego
STARS	Survivability Test Areas
SWDA	Solid Waste Disposal Act
TAP	Tactical Training Theater Assessment Planning Program
T&E	testing and evaluation
TES	threatened and endangered species
TNB	1,3,5-trinitrobenzene
TNT	2,4,6-trinitrotoluene
TRI	Toxicity Release Inventory
TRRP	Texas Risk Reduction Program
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
UCMR	Unregulated Contaminant Monitoring Rule
USAEC	U.S. Army Environmental Center
USC	United States Code
USD (P&R)	Undersecretary of Defense for Personnel and Readiness
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance

1.0 INTRODUCTION

1.1 General

The Navy is engaged in a Training Lands Sustainability program to identify, characterize, and define potential sustainability issues on both land- and sea-based ranges and operating areas (OPAREAs). The goal of this program is to ensure the availability of adequate training and research, development, testing and evaluation (RDT&E) test sites for current and future military operations that protect range resources, the environment, and the public.

The Naval Facilities Engineering Service Center (NFESC) is generating an Initiation Decision Report (IDR) to identify Fleet user needs and define potential problem areas within the Training Lands Sustainability program. The immediate goal is to develop a comprehensive strategy for Navy RDT&E investments that matches current and projected problems with state-of-the-art technology to resolve these needs. Technology gaps are identified to indicate where additional RDT&E must be performed to resolve issues not currently addressed by existing funding. In particular, this effort identifies the critical environmental data needs of range managers responsible for the training requirements of the Navy's forces and their weapon systems. Those needs that require RDT&E investment before implementation will be discussed in the context of an overall RDT&E investment strategy. The ultimate goal is to support mission readiness while maintaining a high level of environmental stewardship and compliance with all applicable laws.

Previous efforts: A Fiscal Year (FY) 02 IDR, titled Environmental Effects of Underwater Ordnance (U.S. Navy, 2004) addressed what was known about munitions constituent fate and effects within marine systems, defined the current state of technology, and recommended specific data gaps for follow-on research and development (R&D). As a result of that study, the Naval Facilities Engineering Command (NAVFAC) 0817 program sponsored four specific ongoing tasks examining:

- Munitions Constituents (MCs) in Marine Matrices (SEDIMENT and WATER) Degradation Research
- Multispecies Marine Sediment Toxicity/Bioaccumulation Research
- Underwater Ordnance Casing Corrosion Research
- Underwater Ordnance Physical Transport and Sediment Erosion/Burial.

These studies are being conducted jointly with the U.S. Army Engineer Research and Development Center-Environmental Laboratory (ERDC-EL), Vicksburg, MS; Space and Naval Warfare Systems Center, San Diego (SSC-SD); and NFESC.

As an addendum to the Underwater Effects IDR, SSC-SD, in coordination with ERDC-EL, is assisting in developing an underwater transport model for inclusion in the existing Army's Risk Assessment Modeling System (ARAMS). ARAMS, as described in Section 4, is primarily a land-based assessment model for munition constituent fate and effects. This effort will extend the ARAMS application to marine systems.

In coordination with NFESC, SSC-SD, and ERDC-EL, the Office of Naval Research (ONR) is sponsoring complimentary research on underwater munitions constituent fate. Ongoing studies include:

- Uptake and Metabolism of TNT in Seawater by Tissue Cultures of Marine Seaweeds
- TNT mineralization rates among natural bacterial assemblages in sediments
- Nucleic acid-based methods for detecting the active bacteria responsible for anaerobic unexploded ordnance (UXO) degradation
- hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) mineralization rates and bacterial degradation.

The Navy's Range Sustainability Program is a critical Fleet support program not only for the Navy, but also for all Department of Defense (DoD). Within this IDR, the approach to identifying requirements and service-specific needs has been coordinated with various organizations, technical workgroups, and subject matter experts. Some of these groups include the Range Sustainability Environmental Program Assessment (RSEPA) work group, the Range Sustainability Group (RSG), the Range Commander's Council (RCC), Navy Range Office (NRO), Strategic Environmental Research and Development Program (SERDP) Range Sustainability Work Group (RSWG), Ordnance Environmental Support Office (OESO), SSC-SD, ONR, and the U.S. Army Construction Engineering Research Laboratory (CERL). A complete listing is provided in Appendix A.

The scope of this report covers technology and programs identified as of calendar year 2003 and some new start programs from early FY2004. It is anticipated that additional range-specific needs will be identified in the near future as the RSEPA program begins implementation and Range Complex Management Plans (RCMPs) are completed. Section 2.0 discusses regulatory issues and includes a brief discussion on Office of Secretary of Defense (OSD) and Navy guidance documents. This chapter also summarizes the recently completed congressionally mandated Navy and Marine Corps range inventories, a synopsis of the key environmental regulatory issues facing ranges, and pertinent case histories that impact, or are anticipated to impact adversely, the use of training lands.

Section 3.0 reviews the current state of technology with respect to the major sustainability issues at Navy range complexes and OPAREAs, where there are numerous efforts funded throughout DoD relating to the eight major Senior Readiness Oversight Council (SROC) issues. Section 4.0 describes environmental efforts in range management, while Section 5.0 assesses and presents technology gaps not covered by current or pending range support programs, as well as recommendations for filling these gaps.

1.2 Navy Range Management Structure

The Navy's Range Sustainment Program is overseen by the NRO established December 1, 2003. NRO is the Office of the Chief of Naval Operations (OPNAV) point of contact for range policy and management oversight, assuming responsibility and resource

sponsorship for all Navy training ranges, RDT&E ranges, target development and procurement, and testing and evaluation (T&E) facilities. The draft NRO organizational structure is presented in Appendix B along with the revised range planning, programming, budgeting, and execution (PPBE) process and a diagram of DoD range organizations.

The Navy's primary range management program is the Tactical Training Theater Assessment Planning Program (TAP), a comprehensive, integrated process to sustain use and access to Navy training ranges and operating areas by addressing encroachment and environmental compliance issues. TAP is composed of five major functional components:

- RCMPs
- Environmental Planning Documentation (National Environmental Policy Act [NEPA])
- Marine Species Density Data (MSDD) for at-sea ranges
- Operational Range Clearance (ORC)
- RSEPA.

RCMPs: While ranges have a good understanding of their current operational role, few have the resources for a vision and coordinated investment plan to transform capabilities for future training requirements (Olsen, 2003). RCMPs will provide individual ranges with Fleet expectations and the investments that may be required to enable the range complex to modernize, transform, and support future Fleet training.

NEPA: Navy ranges must complete environmental planning documentation in accordance with *NEPA* or Executive Order (E.O.) 12114 (Section 2.0). While training and RDT&E operations have been occurring on Navy ranges for many years, each new proposed training or RDT&E action is subject to NEPA and/or E.O. 12114. Such documentation is required for the Navy to understand, characterize, and document environmental impacts occurring on a range and to mitigate where appropriate to lessen potential legislative vulnerabilities. The decision to prepare environmental planning documentation must be grounded on careful consideration of the particular operational and environmental circumstances at the relevant range/OPAREA, and on other factors such as the strategic value of that range/OPAREA, legislative risk, and cost feasibility. Because individual ranges and OPAREAs are aggregated into Range Complexes, environmental planning documentation will usually be prepared on a Complex-by-Complex basis. Ranges must ensure completion of all statutory and procedural documentation for training and RDT&E areas as appropriate. The following additional environmental planning elements must be considered where appropriate:

- Biological assessments
- Marine Mammal Protection Act (MMPA) Permit Analysis
- Essential Fish Habitat Assessment (EFHA) under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)

- Coral Reef Analysis
- Clean Air Act (CAA) Conformity Analysis
- Coastal Consistency Determination
- Cultural Resource Survey/Programmatic Agreement
- Range Air Installation Compatible Use Zones.

MSDD: Chief of Naval Operations (CNO) N45 has committed to sponsor and collect required marine mammal species information through Marine Species Literature Searches (MSLS) and Marine Species Surveys (MSS). The MSLS will identify sources of existing data and delineate areas in need of additional marine mammal surveys. The MSS is required to fill data gaps, in particular marine mammal densities and seasonal abundances, identified in the MSLS. The combined MSLS and MSS will be used as part of Marine Resource Assessment (MRA) reports and other data that supports NEPA/Overseas Environmental Impact Statement (OEIS) planning, as well as training exercises and mission planning. As these data for the marine mammal density focus area become available, additional surveys will be conducted in out-years to develop density data for a wider geographic area within the sea range complexes.

ORC: Commander, U.S. Fleet Forces Command (CFFC), is in the process of establishing a policy and requirements for performing range clearance on Navy Fleet training ranges in accordance with DoD Directive 4715.11 and 4715.12. The ORC policy will establish and maintain a program for routine clearance of impact areas and other range areas that are known, or suspected of, containing munitions and explosives of concern (MEC) debris and target debris. Its purpose is to ensure the safety of range operations and to preserve the long-term vitality of range assets while protecting the public and the environment.

RSEPA: In accordance with the requirements of DoD Directive 4715.11 and DoD Munitions Action Plan (MAP), the Services are required to develop and implement procedures to assess the environmental impacts of munitions on ranges. RSEPA is the Department of the Navy (DON) program developed to fulfill this requirement.

The RSEPA policy manual includes protocols for collecting and analyzing range-specific data and for implementating range management measures that are required to protect human health and the environment. An overview of the RSEPA process is presented in Appendix C.

The Marine Corps is implementing a similar procedure, called the Range Environmental Vulnerability Assessment (REVA) program. REVA is similar to the Navy's RSEPA policy but addresses important differences between the Navy and Marine Corps management of their respective operational ranges. While the Navy manages ranges across the globe, Marine Corps ranges are geographically limited, occurring mainly CONUS (Arizona, California, Hawaii, Georgia, North Carolina, South Carolina, and Virginia).

2.0 PROBLEM DEFINITION

2.1 Overview

The Navy is faced with many environmental issues that affect its land and sea training lands, including weapons test areas. Many of these issues are related directly to the increased encroachment upon military lands, and the steady increase of environmental legislation. The eight encroachment issues identified by DoD are detailed in GAO-02-614, Military Training. They include:

(1) The designation of critical habitat under the Endangered Species Act (ESA) of 1973
(2) The application of environmental statutes to military munitions, including UXO and MCs
(3) Competition for frequency spectrum
(4) The requirement to balance ocean resource protection mandates with training needs
(5) Competition for airspace
(6) The application of CAA regulations specifying requirements for air quality
(7) The application of environmental laws and regulations mandating noise abatement
(8) Unplanned or incompatible commercial or residential development (urban growth) around training ranges and installations.

Issues 3 and 5 are outside the realm of this document. The remaining six issues, as they pertain to the Navy, will be covered. This chapter presents an overview of the problems facing the Navy, beginning with a summary of the Navy and Marine Corps ranges using data collected in their respective range inventory surveys. Pertinent federal, state, and local laws and regulations and their current and potential impacts on range sustainability are described, and case studies are presented to document the impact on the Navy.

OSD has issued several directives and instructions relating to the use and sustainment of ranges. Department of Defense Directive (DoDD) 3200.15, Sustainment of Ranges and Operating Areas (USD [P&R], 2003), establishes policy, responsibilities, and scopes of efforts for DoD and its components during sustainment of test and training ranges and OPAREAs. The other major directives include guidance on Air Installation Compatible Use Zones (AICUZs), and environmental and explosives safety management. They are listed in Appendix D.

2.2 Range Databases

To improve range management and to comply with Congressional requirements, the Navy and Marine Corps have completed inventories of their training and testing ranges. Knowing critical elements about all its bases will allow decision-makers to better allocate resources and establish programs for range sustainability. The information is contained in two databases, one for the Navy and one for the Marine Corps.

The databases differ and are complementary in some ways. The Navy database addresses considerably more range attributes. The Marine Corps database contains less data but has critical information on the current limitations being experienced by operational ranges. This is key data to understanding the magnitude of the encroachment problem.

The Navy prepared an initial survey in 2000–2001. Survey results were compiled into a database and cover the following topics: location (city, county, state, latitude, longitude); points of contact; classification (test, firing, small arms, training, open burning, other, e.g., RDT&E); range type (location of firing and target positions, e.g., water to land); characteristics (total area, impact area, wetland area, water area, date established); accessibility; usage and munitions recordkeeping information; and environmental data.

The Marine Corps completed their range inventory in September 2003. The data collected for the Marine Corps database included range type and classification, range description, location, size, and range usage limitations and their cause. Because different types of data were collected for these surveys, the data presented will not contain direct comparisons.

2.2.1 Navy Range Database. The database contains information for 434 Navy ranges and covers active, inactive, closed, transferred, and transferring ranges. Figure 2-1 summarizes the status of all Navy ranges in the database. As shown, more than half of the ranges are still active, while 24 percent are closed. Inactive ranges are defined as ranges not being used at this time, but which could be used at some later date. There are 59 transferred and transferring ranges. These ranges are closed, cleaned up or undergoing cleanup, and are intended to be owned by another entity. Because the Navy currently has use of only 51 percent of its original range capacity, it is critical that these ranges are managed properly and all considerations are made to keep them active.

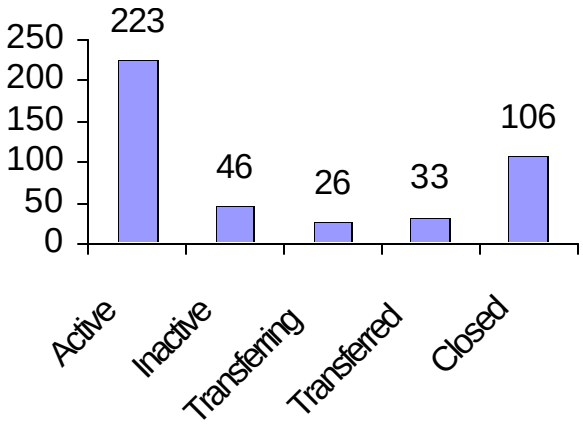

Figure 2-1. Navy Ranges by Status

2.2.1.1 Range Types. Ranges are characterized in the database by the location of both the firing position and impact area. Figure 2-2 shows the number of impact areas on land, in water, or in the air for all Navy ranges. The total number of impact areas is 572. This is greater than the total number of ranges in the database of 434 because many ranges have impact areas in more than one area. For example, the OTA range at Naval Surface Weapons Center Crane is used to fire from land to targets on land and water.

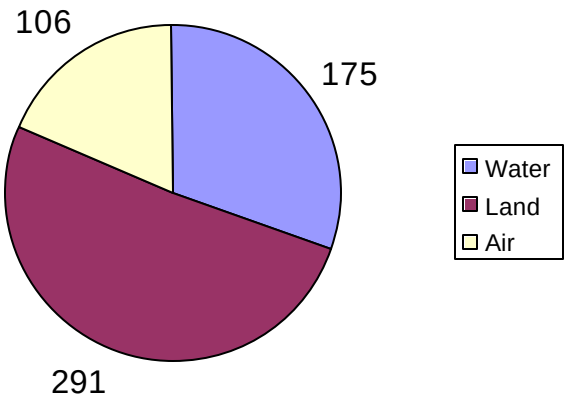

Figure 2-2. Range Impact Areas by Land, Air, or Water

2.2.1.2 Impact Area. The Navy database includes information on the size of each range and the size of the impact area for each range. Figure 2-3 presents impact area acreage for all Navy ranges. Range impact areas are either on land, in water, or in wetlands. For Navy ranges the most surface area for impact areas consists of water, followed by land, and then wetlands.

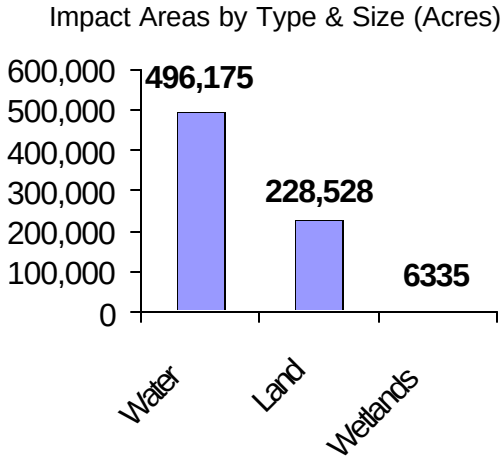

Figure 2-3. Navy Impact Area Acreage

The significant ranges impact area in water is a unique aspect to the Navy and is directly linked to its mission. Ordnance being fired into water creates a challenge for the Navy's sustainable range management program. Figure 2-4 indicates the distance impact areas are from shore at the Navy's water ranges. As seen in this figure there are 83 ranges that require ordnance management in the nearshore environment. The greatest number of regulatory drivers apply to the 0 to 12 mile zone.

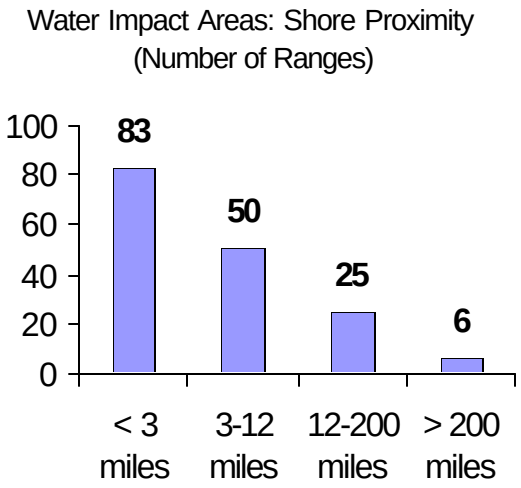

Figure 2-4. Distances to Shore at Navy Water Range Impact Areas

2.2.1.3 Endangered Species. A significant concern at operational ranges is the presence of endangered species. The Navy database contains information about endangered or threatened species at its ranges. Figure 2-5 compares the number of ranges affected by the number of endangered species from a given group of animals and plants. As shown in this figure, the endangered species impacting the most ranges are, in decreasing order, birds, marine mammals, and plants. Figure 2-6 shows the relative abundance of endangered species on federal lands, with DoD lands having the greatest number of species.

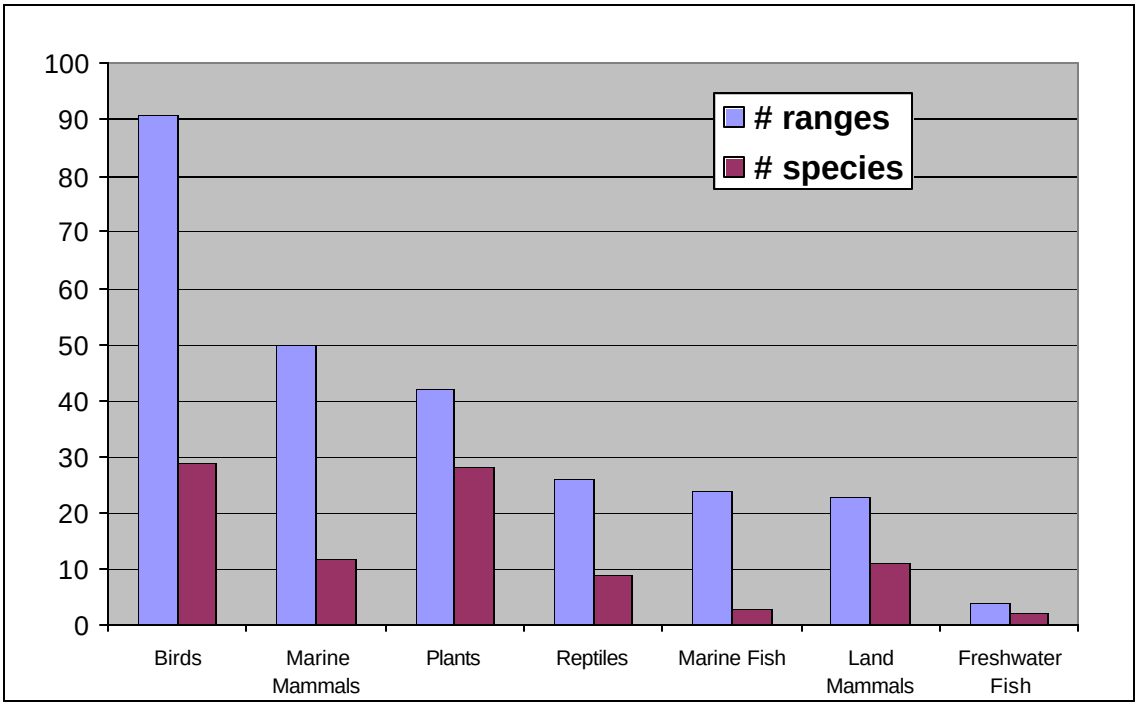

Figure 2-5. Endangered Species Affecting Navy Ranges

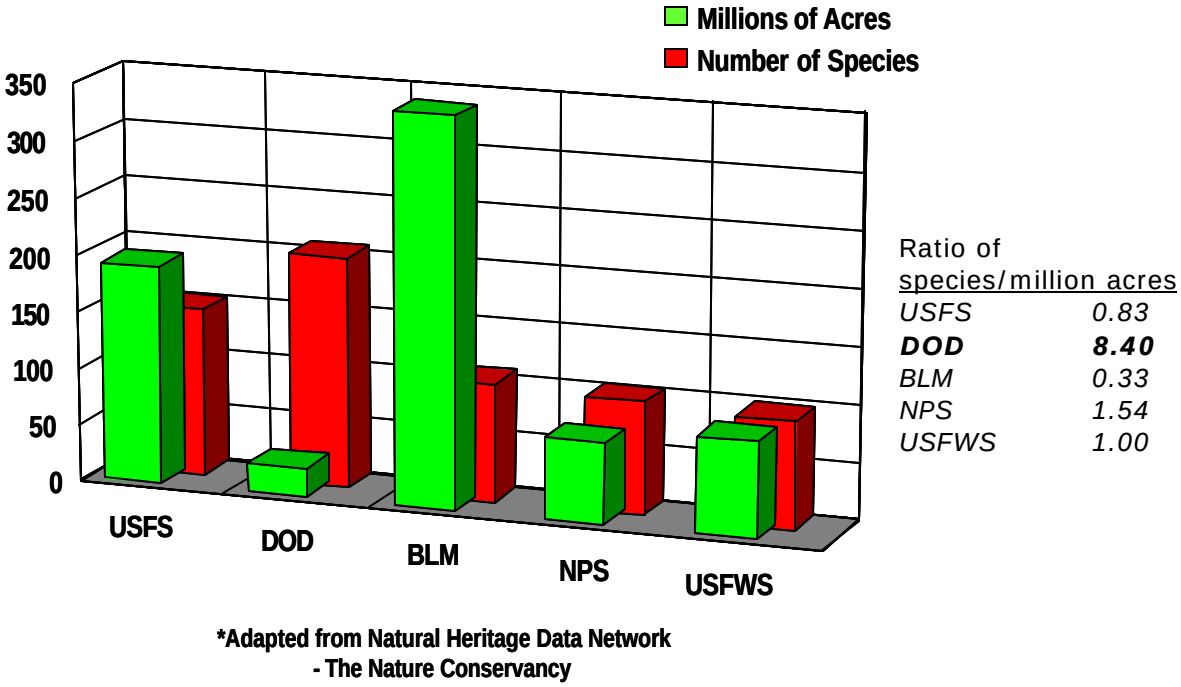

Figure 2-6. Relative Abundance of Endangered Species on Federal Lands

2.2.2 Marine Corps Database. The Marine Corps database consists of more recent data but is not as comprehensive as the Navy's. However, the database provides critical information on the type and number of range limitations that is not included in the Navy database. The Marines have 318 operational ranges at 19 installations covering more than 16 million acres. Of the 318 ranges, the Marine Corps owns 240, or 75 percent. Also included in the database are general descriptions of soil type, vegetation, and the existence or nonexistence of wetlands and threatened and endangered species (TES).

2.2.2.1 Range Status. The Marine Corps database provides the status of each range as operational and nonoperational. Use classification also is indicated, as well as whether the use is current or historical. For example, a range that historically performed open burning but continues to be used for other purposes is operational. Including knowledge of past operations is helpful in sustaining operational range readiness.

2.2.2.2 Range Limitations. Some of the best information from the Marine Corps database pertains to activities that limit full range utilization. Unfortunately, this information was not included in the Navy database. However, similar conclusions may be drawn between the limitations experienced by the Marines and those for Navy land-based ranges. Figure 2-7 shows the limitations experienced at operational Marine Corps ranges.

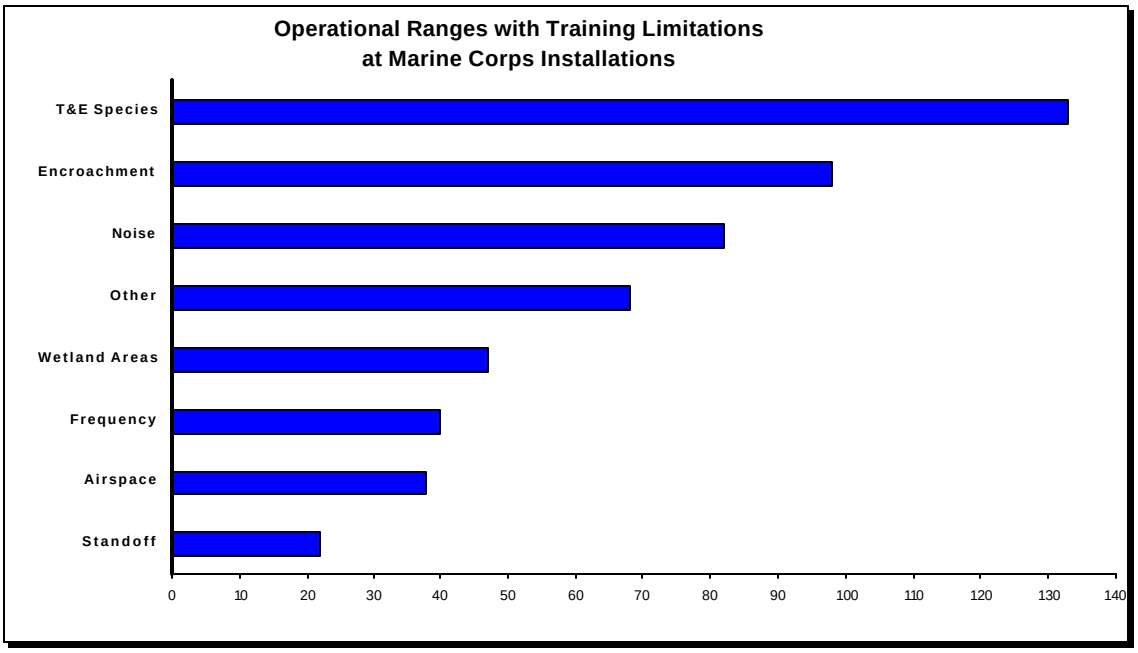

Figure 2-7. Training Limitations

2.3 Major Environmental, Safety, and Health Laws and Regulations

Environmental, safety, and health (ESH) laws are implemented through a series of regulations promulgated by the U.S. Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), other agencies of the U.S. government, and state/local regulatory bodies. These external regulations are then supplemented by DoD directives and Navy regulations, which must be implemented by individual Program Managers. A depiction of the number of laws impacting the Navy/Marine Corps is shown in Figure 2-8.

It is imperative that range managers have a comprehensive understanding of the environmental laws affecting their ranges. This guide is designed to give managers a brief overview of the major laws and E.O.s that may apply to their range operations. Key Navy documents

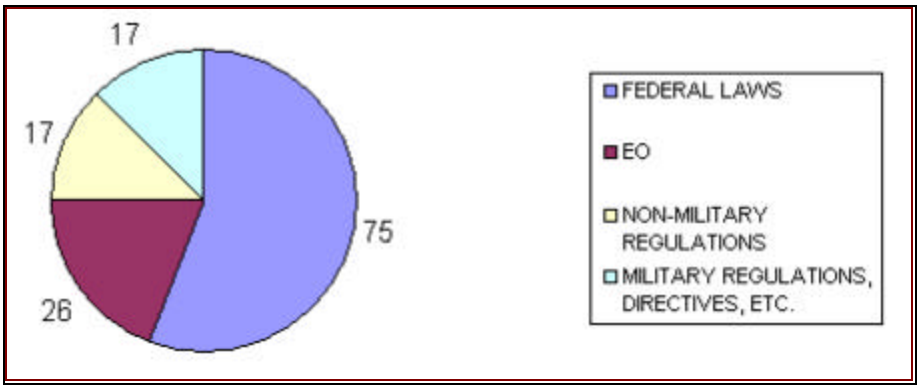

Figure 2-8. Environmental Laws and Regulations Impacting the Navy/Marine Corps

providing guidance on implementation of these laws are Operational Navy Instruction (OPNAVINST) 5090.1B for environmental programs, and OPNAVINST 5100.23D for occupational safety and health programs. The DoD 5000 series requires additional environmental documentation for all DoD (including Navy) Acquisition Programs.

Environmental statutes and Executive Orders constitute an external constraint, beyond the range and program managers' control, on system design, construction, modification, testing, operation, support, maintenance, repair, demilitarization, and disposal.

In addition to current ESH regulations, range and program managers should recognize the changing nature of codes, standards, and regulations. These environmental requirements impact the costs associated with using a particular range. Ranges with more environmental requirements will be more expensive to use. Range managers should coordinate with their local ESH offices to analyze the available pollution prevention and compliance alternatives and to develop their compliance strategy.

If the range is located in a foreign nation, the environmental regulations applicable to the foreign country must be considered. (DoD policy and standards for environmental matters in foreign countries are published in the DoD "Overseas Environmental Baseline Guidance Document" [OEBGD].) The applicability of U.S. laws to overseas ranges will be established in each foreign nation's Status of Forces Agreement (SOFA) along with the OEBGD. Overseas range managers will need to refer to these documents for guidance.

A summary of the major applicable laws, regulations, and other directives is presented in Table 2-1. A master list of applicable laws, regulations, and other directives is provided in Appendix D.

The following discussion provides a brief overview of the more common environmental regulations and policies constraining or having the potential to constrain operations on the Navy's range complexes. It is not intended to be an exhausted list or discussion.

2.3.1 Clean Air Act (CAA). The Clean Air Act controls the emission of pollutants into the atmosphere. The CAA has five principal objectives: (1) maintain National Ambient Air Quality Standards (NAAQS), (2) protect the public from emissions of hazardous or toxic air pollutants, (3) protect clean air from significant deterioration, (4) protect the stratospheric ozone, and (5) control acid deposition from burning of fossil fuels by utilities. These objectives are met through a complex set of overlapping programs that are implemented at the federal, state, and local level. It may be necessary for ranges to conduct several different air analyses and obtain permits in order to satisfy all CAA requirements.

2.3.2 Clean Water Act (CWA). The Clean Water Act controls the discharges of pollutants into waters of the United States. The objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA established programs to regulate the discharge of waters from point sources (e.g., discharge pipes), nonpoint sources (NPSs) (e.g., stormwater runoff) and discharges to wetlands (dredge or fill material). These programs, in turn, generally are administered by state environmental agencies in accordance with their EPA-approved state water quality management plans. Ranges may need to obtain National Pollutant Discharge Elimination System (NPDES) permits to comply with the CWA, particularly as the EPA and the states increase the use of watershed-based permitting strategies and receiving water quality-based (vs. technology-based end-of-pipe) permit specifications. At this time, ranges do not normally get NPDES permits. Some state regulatory agencies are beginning to

Table 2-1. Major Applicable Laws, Regulations, and Other Directives[(a)]

LAWS - FEDERAL	Currently Impacts	May Impact in Future	Not Applicable
Clean Air Act of 1970, as amended (42 United States Code [USC] 7401 *et seq.*)	X		
Clean Water Act of 1977, PL 95-217 (33 USC 1251 *et seq.*)	X		
Coastal Zone Management Act of 1972, PL 92-583 (16 USC 1451-1465)	X		
Comprehensive Environmental Response, Compensation, and Liability (CERCLA) Act of 1980, as amended (42 USC 9601 *et seq.*)	X		
Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 (42 USC 11001 *et seq.)*	X		
Endangered Species Act of 1973, PL 93-205, as amended (16 USC 1531-1534)	X		
Federal Facility Compliance Act of 1992, PL 102-386 (42 USC 6901 note, 6908)	X		
Magnuson-Stevens Fishery Conservation and Management Act of 1976 (16 USC 1801 *et seq.*)	X		
Marine Mammal Protection Act of 1972, PL 92-522, as amended (16 USC 1361-1421h)	X		
Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 USC 1401 *et seq.* and 16 USC 1431 *et seq.*)	X		
Migratory Bird Treaty Act of 1918, 40 Stat 755, as amended (16 USC 703-712)	X		
National Environmental Policy Act of 1969, PL 91-190 (42 USC 4321-4370d)	X		
National Historic Preservation Act of 1966, PL 89-665, as amended (16 USC 470-470x-6)	X		
Noise Control Act of 1972 (42 USC 4901 et seq.)	X		
Occupational Safety and Health Act of 1970, PL 91-596 (29 USC 651 *et seq.*)	X		
Pollution Prevention Act of 1990 PL 101-508 (42 USC 13101–13109)	X		
Resource Conservation and Recovery Act of 1976, PL 94-580, as amended (42 USC 6901 *et seq.*)	X		
Rivers and Harbors Appropriations Act of 1899, 30 Stat. 1141, as amended (33 USC 401-403)	X		
Safe Drinking Water Act of 1974, PL 93-523, as amended (42 USC 300f-300j-26)	X		
Solid Waste Disposal Act of 1965, PL 89-272, as amended (42 USC 3251 *et seq.*)	X		
Superfund Amendments and Reauthorization Act (SARA) of 1986, PL 99-499		X	
Toxic Substances Control Act of 1976 (15 USC 2601 *et seq.*)	X		
EXECUTIVE ORDERS			
Executive Order 12114 Environmental Effects Abroad of Major Federal Actions, January 4, 1979 (44 FR 1957)	X		
Executive Order 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations, February 11, 1994 (59 FR 7629)	X		

Table 2-1. Major Applicable Laws, Regulations, and Other Directives (Continued)

NOTICES, POLICIES AND REGULATIONS	Currently Impacts	May Impact in Future	Not Applicable
Final Notice of Issuance and Modification of Nationwide Permits, March 9, 2000 (65 FR 12818)	X		
U.S. Fish and Wildlife Service List of Endangered and Threatened Wildlife and Plants (50 Code of Federal Regulations [CFR] 17.11 and 17.12)	X		
National Register of Historic Places (36 CFR 60)	X		
Protection of Historic and Cultural Resources (36 CFR 800)	X		
Regulations for Implementing NEPA (Council on Environmental Quality) (40 CFR 1500)	X		
"Agreements to Limit Encroachment and Other Environmental Constraints on Navy and Marine Corps Installations" Assistant Secretary of the Navy (Installations and Environment) Memorandum of 23 Jan 2003	X		
Air Installations Compatible Use Zones (AICUZ) Program OPNAVINST 11010.36B		X	
Archaeological and Historic Resources Management (Department of Defense Directive [DoDD]) 4710.1 (June 21, 1984)	X		
Environmental and Explosive Safety Management on Department of Defense Active and Inactive Ranges Outside the United States, DoD Directive 4715.12 (August 17, 1999)	X		
Environmental and Explosive Safety Management on Department of Defense Active and Inactive Ranges Within the United States, DoD Directive 4715.11 (August 19, 1999)	X		
Environmental and Natural Resources Program Manual OPNAVINST 5090.1B (October 17, 2002)	X		
Environmental Compliance and Protection Manual, Marine Corps Order (MCO) P5090.2A	X		
Military Munitions Rule (MMR), 62 FR 6621	X		
Navy "At Sea" Policy -- UASN Robert Pirie Memorandum (December 28, 2000) Compliance with Environmental Requirements in the Conduct of Naval Exercises or Training at Sea.	X		
Range Air Installations Compatible Use Zones (RAICUZ) Program OPNAVINST 3550.1	X		

(a) Table summarizes the major principal federal laws, Executive Orders, regulations as well as other directives and instructions and their expected influence on Range Sustainability as set forth in this document.

request that ranges apply for NPDES permits. If a range is asked to obtain an NPDES permit, OPNAV N45 should be promptly notified.

2.3.3 Coastal Zone Management Act (CZMA). The Coastal Zone Management Act of 1972 established the Coastal Zone Management Program (CZMP). The National Oceanic and Atmospheric Administration (NOAA) administers the CZMP. Thirty-four states and territories, which have federally approved coastal management plans, handle the daily management of the Program. NOAA manages the remaining states and territories' programs. In addition, the 1972 law established a system of criteria and standards for requiring that federal actions be conducted in a manner consistent with the federally approved plan. The standard for determining consistency varied depending on whether the federal action involved a permit, license, financial assistance, or a federally authorized activity.

Ranges located within the coastal zone will need to evaluate if their actions will affect coastal waters or resources. If the actions have any effects, the range must ensure compliance with the state's coastal management program and consult with the state agency administering the program.

2.3.4 Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act (CERCLA/SARA). CERCLA sets up a protocol for determining liability for environmental cleanup efforts. The Act addresses past, present, and potential releases of hazardous pollutants, which may pose an imminent and substantial danger to the public welfare. The Act established provisions for taxing users of hazardous materials in order to pay for cleanup efforts (Superfund Program).

2.3.5 Emergency Planning and Community Right-to-Know Act (EPCRA). The EPCRA was established to promote emergency planning and preparedness for chemical releases at both the state and local levels, and to provide the legal framework enabling residents and local governments to obtain information about potential chemical hazards present in their communities. The Act requires industrial facilities to provide quantitative information on releases to the environment resulting from normal business operations. Therefore, a facility's discharges of air and water pollutants and wastes disposed of off site are now public information. Ranges must work with the local installation to determine the tracking and reporting requirements necessary to ensure compliance with EPCRA.

2.3.6 Endangered Species Act. The ESA was passed to help prevent the extinction of fish, wildlife and plant species through the listing of endangered and threatened species of plants and animals, and the designation of critical habitat. It prohibits all persons subject to U.S. jurisdiction, including federal agencies, from "taking" endangered species. The taking prohibition includes any harm or harassment, including habitat modification, and applies within the U.S. and on the high seas. "Harm" in the definition of "take" in the ESA means an act that actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. For example, the detonation of explosives or ordnance during an operation, while not affecting any protected species directly, can constitute a take by affecting critical habitat, and/or other resources required by that species.

As critical habitat is continually being threatened by growth and development activities, ranges will increasingly be looked at as "safe harbors" for endangered and threatened species. The range manager and the local installation's Environmental Office (in cooperation with the U.S. Fish and Wildlife Service [USFWS]) must determine whether threatened or endangered species will be affected by range activities. If threatened or endangered species may be impacted, conservation efforts must be considered. The consultations for ESA are typically completed as part of the NEPA process. This law may impact a range depending on the locations, timing, and methods used for training/testing.

2.3.7 Executive Order 12114, Environmental Effects Abroad of Major Federal Action. Presidential E.O. 12114 requires an environmental analysis for major actions conducted outside the United States to determine whether any significant environmental impacts exist. This applies to all actions in the global commons or within the territory of another nation with which the U.S. does not have Final Governing Standards. The process is similar to the NEPA process.

In accordance with the E.O., every federal agency proposing a federal action having significant effects on the environment outside of the geographical borders of the United States, its territories or possessions, and which are not exempted by the E.O., are required to have implementing procedures. The implementing procedures provide for the preparation of different types of documents, including:

1. Environmental impact statements (including specific and generic program statements)
2. Bilateral or multilateral environmental studies
3. Concise reviews of the environmental issues involved, Environmental Assessments (EAs), summary environmental analyses, or other appropriate documents.

The type of document to be prepared is based on different categories of actions identified in the E.O. and further described in OPNAVINST 5090.1B.

2.3.8 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. E.O. 12898 requires each federal agency to make achieving environmental justice a part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations in the U.S. and its territories. Each federal agency must conduct its programs, policies, and activities that substantially affect human health or the environment such that they do not adversely impact minority or low-income populations. Range managers must ensure that range activities do not have a disproportionate impact on populations covered under this E.O.

2.3.9 Federal Facilities Compliance Act. The Federal Facilities Compliance Act of 1992 requires government facilities to comply with the Resource Conservation and Recovery Act (RCRA) requirements for solid and hazardous wastes. RCRA inspection records must be made available to the public, and the costs for EPA inspections must be paid by the federal agency owning or operating the facility. The act waives federal immunity for RCRA violations and authorizes EPA or states to take administrative and civil enforcement actions against federal agencies. Federal agencies are exempt from criminal actions but federal employees are subject

to criminal sanctions. Ranges and all associated personnel must comply with this act. Its requirements can be met by working with the local installations.

2.3.10 Magnuson-Stevens Fishery Conservation and Management Act. The Magnuson-Stevens Fishery Conservation Management Act established a 200-mile fishery conservation zone, which is now known as the Exclusive Economic Zone (EEZ), and established Regional Fishery Management Councils composed of federal and state officials, including the USFWS. The Act provides for management of fish and other species in the EEZ under plans drawn up by the Regional Councils and reviewed and approved by the Secretary of Commerce. It provides for regulation of foreign fishing in the management zone under governing international fishing agreement (GIFAs) and vessel fishing permits. It also provides a mechanism for preemption of state law by the Secretary of Commerce.

Major amendments to the Act were enacted on October 11, 1996. The amendment most likely to impact range operations mandates the Secretary of Commerce to promulgate guidelines for identification of Essential Fish Habitat (EFH) by Fishery Management Councils. Other federal agencies are required to consult with the Secretary when actions they take impact designated Essential Fish Habitat.

2.3.11 Marine Mammal Protection Act. The MMPA was enacted in 1972 to protect marine mammals and establish a marine mammal commission. The MMPA prohibits the "taking" (i.e., any harm or harassment) of marine mammals incidental to marine activities in the United States or on the high seas, subject to limited exceptions. Several marine mammal species are also listed as "threatened" or "endangered," requiring addressing additional regulations promulgated under the ESA. Under the 1994 MMPA amendments, the Congress statutorily defined the term "harassment" to mean any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A Harassment); or

- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B Harassment).

When an activity may harm or harass marine mammals, the potential for a "take" exists and consultation with the National Marine Fisheries Service (NMFS) is required. A permit is required if any animals will be harmed.

The Navy sea range managers should be aware of the resident and migratory marine mammals on their ranges and range activities that could impact these mammals under the MMPA. Public awareness of specific environmental issues related to the protection of marine mammals has been elevated for the Navy in the area of MMPA with the testing and training of the Navy's anti-submarine warfare systems. Sea range managers should work closely with their environmental office to ensure activities on their ranges are compliant with MMPA and required environmental documentation is in-place and current. The Navy is currently undertaking MRAs for all its sea ranges to help identify and document marine mammals and other marine resources on its sea ranges. These MRAs should be available to sea range managers soon.

2.3.12 Marine Protection, Research, and Sanctuaries Act. The Marine Protection, Research, and Sanctuaries Act of 1972 has three Titles. Titles I and II are the most likely to impact range complexes and has already affected PMTC, Channel Islands. Title II authorized an ocean dumping and research program. Title I authorized the EPA to regulate ocean dumping of industrial wastes, sewage sludge, and other wastes (such as radiological, chemical, and biological warfare agents; high-level radioactive wastes; and medical wastes) through a permit program. The basic objective of the permit program is to "prevent or strictly limit the dumping into ocean waters of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities." The Secretary of the Army is authorized to issue permits for dredged material disposal, and EPA is authorized to designate appropriate dump sites. This Title has been amended several times to include additional wastes such as low-level radioactive wastes and to make other changes to the permit program. The necessary permits for any ocean dumping during range activities at sea must be obtained.

Title III authorized the Secretary of Commerce to designate national marine sanctuaries. Some ranges are adjacent or may overlap designated waters. Training and testing exercises will need to be coordinated and possibly require approval by the individual sanctuary management group.

2.3.13 Migratory Bird Treaty Act (MBTA). The Migratory Bird Treaty Act (MBTA) of 1918 was intended to protect migratory birds from extinction due to hunting and the use of feathers and eggs in decorative items. A permit is required to capture or kill a migratory bird. The MBTA does not have a permit for incidental (as opposed to intentional) takes, which is what would most likely occur at ranges. This law has had a profound affect on the Pacific Fleet's Farallon de Medinilla Target Range in the northern Mariana Islands. The Pacific Fleet's ability to conduct training on Farallon de Medinilla is subject to litigation brought by an environmental group seeking to stop live-fire training on the grounds that some migratory, but not necessarily endangered or threatened, birds are harmed in violation of the MBTA. In response, Congress in the FY03 Defense Authorization Bill authorized the USFWS in conjunction with the DoD to create a permit for military activities. This permit is not yet available. Range managers need to work with their local regulators to ensure compliance with MBTA until the range can apply for the new permit.

2.3.14 Military Munitions Rule. The Military Munitions Rule was authorized in Section 107 of the Federal Facilities Compliance Act of 1992. Section 107 required the EPA, in consultation with the DoD and the states, to issue a rule identifying when conventional and chemical military munitions become hazardous waste under RCRA, and to provide for protective storage and transportation of that waste. This rule amends existing regulations regarding emergency responses and RCRA manifest requirements. It establishes the regulatory definition of solid waste as it applies to three specific categories of military munitions: (1) unused munitions; (2) munitions being used for their intended purpose; and (3) used or fired munitions. Ranges will need to work with their local environmental office to ensure range procedures are in compliance.

2.3.15 National Environmental Policy Act (NEPA). Federal agencies that fund, support, permit, or implement major programs and activities are required to take into consideration the environmental consequences of proposed actions in the decision-making process under the National Environmental Policy Act of 1969, Title 42, USC, Section 4321, et seq. (42 USC 4321 et seq.). The intent of NEPA is to protect, restore, or enhance the environment through

well-informed federal decisions. The Council on Environmental Quality (CEQ) was established under NEPA to implement and oversee federal policy in this process. The CEQ issued regulations implementing the process, which are located in Title 40, Code of Federal Regulations (CFR) Parts 1500-1508 (40 CFR 1500-1508). In the Navy, the NEPA process is set forth in OPNAVINST 5090.1B as promulgated in 32 CFR 775, and in the Marine Corps via MCO P5090.2A. For federal actions abroad, E.O. 12114 further implements NEPA principles. NEPA and E.O. 12114 do not prevent the federal government from taking actions that will impact the environment. It does require that decision makers know all the impacts before a decision is made and the action taken. For help in determining the right level of NEPA documentation, contact your local installation's environmental staff.

2.3.16 National Historic Preservation Act. The National Historic Preservation Act (NHPA) created the Advisory Council on Historic Preservation (ACHP), an independent federal agency, to advise the President and Congress on matters involving historic preservation. The ACHP is authorized to review and comment on all actions licensed by the federal government which will have an effect on properties listed in the National Register of Historic Places, or eligible for such listing. Federal actions include, but are not limited to, construction, rehabilitation, and repair projects, demolition, licenses, permits (e.g., Clean Water Act Section 404 permits), loans, loan guarantees, grants, and federal property transfers. Properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization may also be determined to be eligible for inclusion on the National Register.

Section 106 of the NHPA requires that a federal agency involved in a proposed project or activity is responsible for initiating and completing the review of all actions which may affect a property listed on the National Register, or which may affect a property eligible for listing. The agency must confer with the State Historic Preservation Officer (an official appointed in each state or territory to administer the National Historic Program) and the NHPA. The federal agency is also required to consult with any Indian tribe or Native Hawaiian organization that attaches religious and cultural significance to properties as described above.

2.3.17 Noise Control Act. The Noise Control Act of 1972, amended by the Quiet Communities Act of 1978, promotes an environment for all Americans free from noise that jeopardizes their health and welfare. EPA was delegated authority to coordinate all noise legislation and policies enacted by federal agencies, and to review federally sponsored programs and projects that deal with the subject of noise. This law may impact ranges depending on the location, time, and methods of testing/training chosen.

2.3.18 Occupational Safety and Health Act. The Occupational Safety and Health Act was passed by Congress to ensure safe and healthful conditions for the Nation's workforce. Standards have been set for record keeping and reporting, exposure levels to chemicals and other agents such as noise and dust, hazardous waste operations, hazard communication (employee training), and equipment/facility design standards. Ranges must comply with all OSHA requirements. This includes providing the documentation to prove the adequate ESH training of all personnel.

2.3.19 Pollution Prevention Act. In the Pollution Prevention Act of 1990, Congress declared it to be the national policy of the United States that pollution should be prevented or reduced at the

source whenever feasible. Source reduction practices, which prevent wastes from being generated, are the focus of this Act; treatment and disposal of wastes do not constitute pollution prevention.

A number of E.O.s require federal agencies to implement pollution prevention practices. E.O. 13101 requires the government to buy products containing recycled materials or considered "environmentally preferable." Reducing energy and water use is the main thrust of E.O. 13123. E.O. 13148 requires pollution prevention strategies to be established by an agency. Ranges in conjunction with Program Managers are responsible for finding testing/training methods that eliminate or minimize the generation of hazardous waste. Some hazardous waste will be unavoidable, but the methods chosen should not increase hazardous waste amounts.

2.3.20 Resource Conservation and Recovery Act. Congress passed the RCRA in 1976 to address control of solid waste disposal, including the disposal of wastes considered hazardous. RCRA defines hazardous waste, among other things, as solid waste that may pose a substantial present or potential hazard to human health and the environment when improperly treated, stored, transported, disposed, or otherwise managed.

The primary responsibility for determining whether wastes exhibit hazardous characteristics rests with the generators. Once a waste has been determined to be hazardous, those who generate, transport, or dispose of it must comply with the variety of notification, record keeping, permitting and monitoring requirements under RCRA. In addition to the extensive federal RCRA regulations, individual states are allowed to enforce more stringent regulations.

Individual shore activities have primary responsibility for assuring compliance with RCRA requirements. Ranges need to work with their local installations to ensure compliance.

2.3.21 Rivers and Harbors Appropriations Act. Under Section 10 of the River and Harbors Act of 1899, the building of any wharfs, piers, jetties, and other structures is prohibited without Congressional approval, and excavation or fill within navigable waters requires the approval of the Chief of Engineers. Service concerns include contaminated sediments associated with dredge or fill projects in navigable waters.

Section 13 of the Act authorizes the Corps of Engineers to issue permits for the discharge of refuse matter into or affecting navigable waters. This section was modified by Title IV of the federal Water Pollution Control Act Amendments of 1972, which established the NPDES Permits.

The USFWS is granted the authority to review and comment on the effects on fish and wildlife of activities proposed to be undertaken or permitted by the Corps of Engineers by the Fish and Wildlife Coordination Act.

Ranges must obtain the necessary permits for any actions that fall under these sections. Coordination for the permits must include not only the Corps of Engineers but also the USFWS and any applicable state or local agencies.

2.3.22 Safe Drinking Water Act (SDWA). The SDWA was established 1974 to protect drinking water quality in the U.S. The SDWA focuses on all waters used or potentially used for drinking water. It applies to surface and groundwater sources. The EPA was authorized to create standards for safe drinking water. All owners and operators of public drinking water systems are required to comply with the primary standards. State governments were given the power by EPA to establish secondary standards for their individual states. Range managers are

impacted by SDWA if their range is on top of a groundwater drinking water source or drains into a surface water body used for drinking water.

2.3.23 Sikes Act Improvement Amendments. The Sikes Act as amended in 1986 requires the Secretary of each military department to use trained professionals to manage the wildlife and fishery resources under his jurisdiction, and requires federal and state fish and wildlife agencies be given priority in management of fish and wildlife activities on military reservations. The Sikes Act Improvement Amendments of 1997 (Public Law 105-85) requires military installations to prepare ecosystem-based management plans to conserve and restore natural resources within their respective jurisdictions. It added that part of each Integrated Natural Resources Management Plan (INRMP) prepared under this Act should provide for the sustainable use by the public of natural resources, to the extent that the use is not inconsistent with the needs of fish and wildlife resources.

2.3.24 Solid Waste Disposal Act. The Solid Waste Disposal Act (SWDA) requires that federal facilities comply with all federal, state, and local requirements concerning the disposal and management of solid wastes. The SWDA encourages beneficial reuse of waste. In addition, DoD has developed policy that prioritizes waste disposal options as follows:

- Source reduction
- Recycling
- Energy recovery
- Waste treatment
- Contained disposal.

Each activity is required to develop a Solid Waste Management Plan that describes procedures for handling various recyclable and waste materials. Ranges need to work with their local installations to ensure compliance with established plans.

2.3.25 Superfund Amendments and Reauthorization Act (SARA). SARA was an amendment made to CERCLA in 1986. SARA reauthorized the funding provisions of CERCLA and made several changes to the cleanup program based on the EPA's experience in administering the first six years of the Superfund program.

2.3.26 Toxic Substances Control Act (TSCA). The TSCA regulates the manufacture, distribution, use and disposal of chemicals. TSCA has provisions covering asbestos, polychlorinated biphenyls (PCBs), lead paint exposure, and existing as well as new chemicals. One main goal of TSCA is understanding and regulating a new chemical's risk to humans and the environment before its introduction into commerce. Ranges should work with their local installations to see if they fall under the installations permits. If so, the range manager needs to ensure that the range complies with all of the permits.

2.4 Case Studies

The case studies provided below illustrate several environmental issues that have impacted the training activities of the Navy and other military branches. The first case study addresses air quality, the second wild fires, and the third sonar and marine mammals.

2.4.1 Navy Air Pollution Transport Issues and Their Resolution. Several air pollution transport issues have recently confronted the Navy. Examples are (a) a threatened movement of commercial shipping lanes off the coast of Southern California into the Navy's offshore test and training range which, if successful, could have drastically curtailed the Navy's use of that range; (b) a threatened reclassification of "air quality" to "severe" of the area occupied by the Navy's China Lake Test Range for both ozone and PM_{10} (particulate matter less than 10 microns in diameter), severely limiting the Navy's capability to sustain and expand its ongoing test programs and inhibit the initiation of new test efforts there; and (c) a less specific EPA concern regarding the distance offshore from which emissions from ocean-going traffic may have an impact on continental United States air quality.

The Navy was able to address the above issues with combinations of metrological and air quality modeling of the areas of concern and, in each case, provide a scientific basis for the Navy to justify and maintain the integrity of its affected ranges.

2.4.1.1 Off-Shore Impact of Ship Operations on Southern California Coastal Areas

Port of Los Angeles Ship Channel Study: The Port of Los Angeles, to reduce the presumed impact of emissions from offshore commercial ship traffic on the quality of onshore atmospheric conditions, proposed that the existing commercial shipping lanes along the Southern California coast be moved further offshore. Such a move would have caused the "new" commercial shipping lanes to intersect with the existing Navy sea training and test range located in that area and could have served as a major impediment for the Navy's continued capability for testing and training there. As a result, the Navy participated with state and local officials to conduct simulations of the metrology of the area, and supported by measurements of atmospheric pollutants, demonstrated that the proposed move could actually increase the amount of pollutants reaching the shore at other points along the coast. The analysis also showed that a strategy of reducing the shipping speed would reduce the effect of the emissions produced and be more effective in reducing onshore impacts. State and local officials agreed and the shipping lanes were not moved.

Figure 2-9 shows the results of wind and streamline analyses and how emissions from offshore ships were generally apportioned along the Southern California coast using mean annual surface winds. Figure 2-10 shows how nitrogen oxide (NO_x) emissions from commercial shipping were transported onto the California coastline during a specific air pollution episode of the Southern California Ozone Study (SCOS).

Other Offshore Emissions Concerns: The Navy performed a meteorologically based estimate of the transport of offshore emissions onto the shore as a basis for estimating

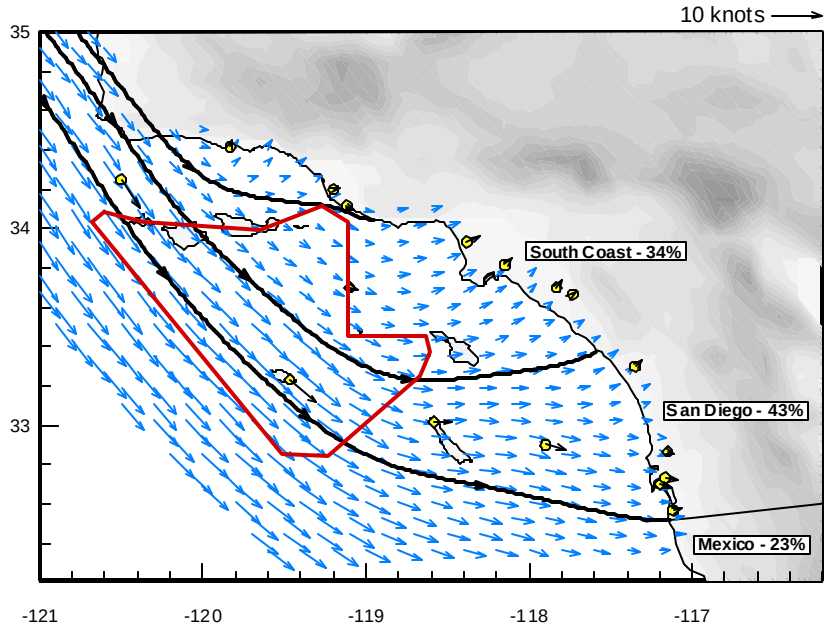

Figure 2-9. Emission Transport Estimate for NEPA Air Quality Analysis Using Mean Annual Surface Winds

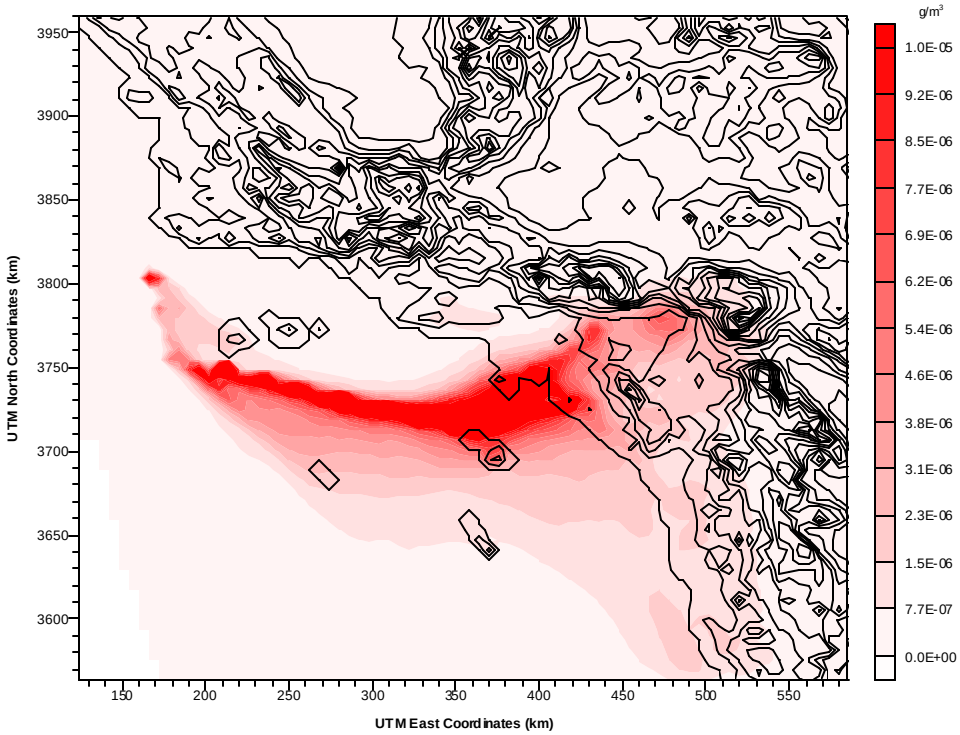

Figure 2-10. Simulated NO_x Concentration Time Average, Proposed Shipping Lane, 2-6 September 1997

how far offshore emissions need to be to avoid impacting onshore air quality. Figure 2-11 illustrates a result of this study for the continental United States for the West, East and Gulf Coasts.

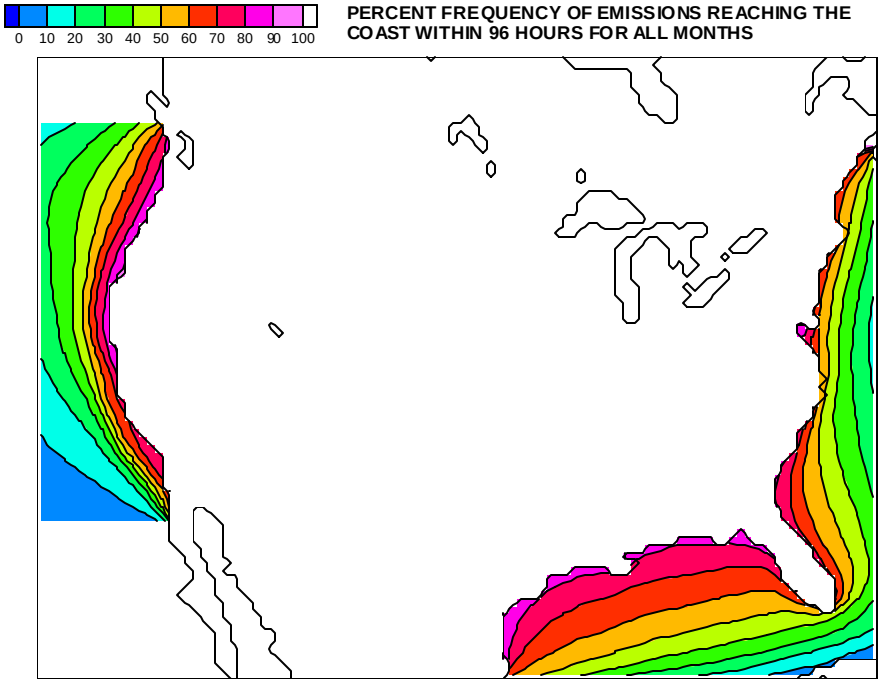

Figure 2-11. Percent Frequency of Emissions Reaching the Coast Within 96 Hours for All Months

2.4.1.2 Air Quality Modeling. In a related air quality modeling effort, the Navy has used the EPA's Community Multiscale Air Quality (CMAQ) to assess the transport and transformation of gaseous and aerosol pollutants. Figure 2-12 shows calculated onshore ozone profiles during a SCOS episode. Use of this and newer atmospheric models will become increasingly important in providing the Navy with an independent capability for assessing the air quality impacts of emission-producing activities and the effect of proposed regulations when issues like conformity and impacts on surrounding communities are important.

2.4.1.3 Air Quality Reclassification. A proposed increase of the Kern County (California) air pollution classification to 'severe' threatened the ability of the Navy Land Range at China Lake and of Edwards Air Force Base (AFB) to sustain and expand existing programs and support new testing- and training-related business. As a result Navy and Air Force personnel worked with the compliance staffs of the California Air Resources Board and the EPA to demonstrate that the proposed reclassification for Kern County should not apply to East Kern County (where the Navy and Air Force bases are located). This was because the observed ozone exceedances in Eastern Kern were shown to be due to transport of pollutants from the Los Angeles area (Figure 2-13 illustrates these transport streamlines). The State Air Resources Board and the EPA agreed.

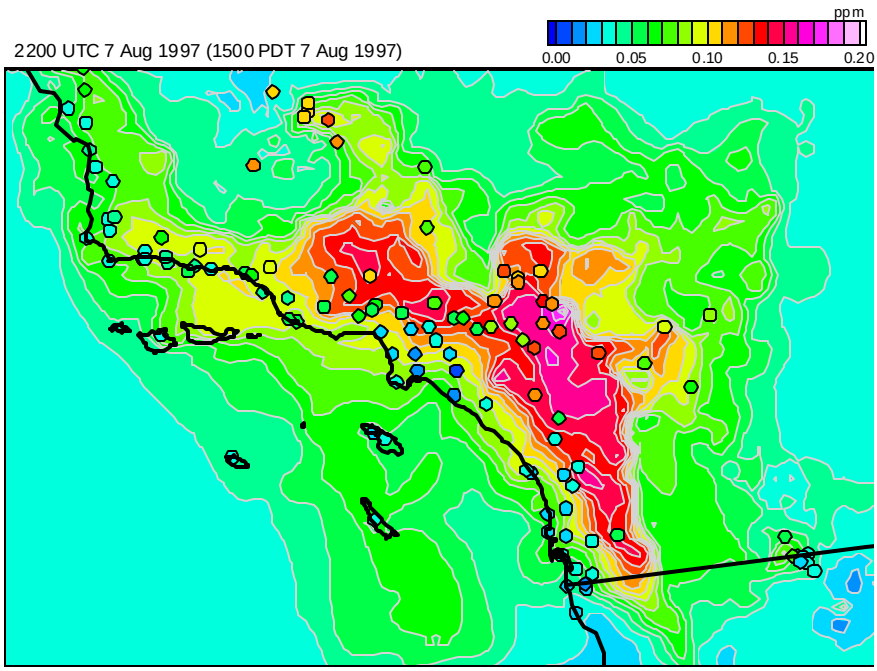

Figure 2-12. Surface Ozone Concentration Using CMAQ Air Quality and MM5 Meteorological Models for Simulation and Correlation of Ambient Measurements

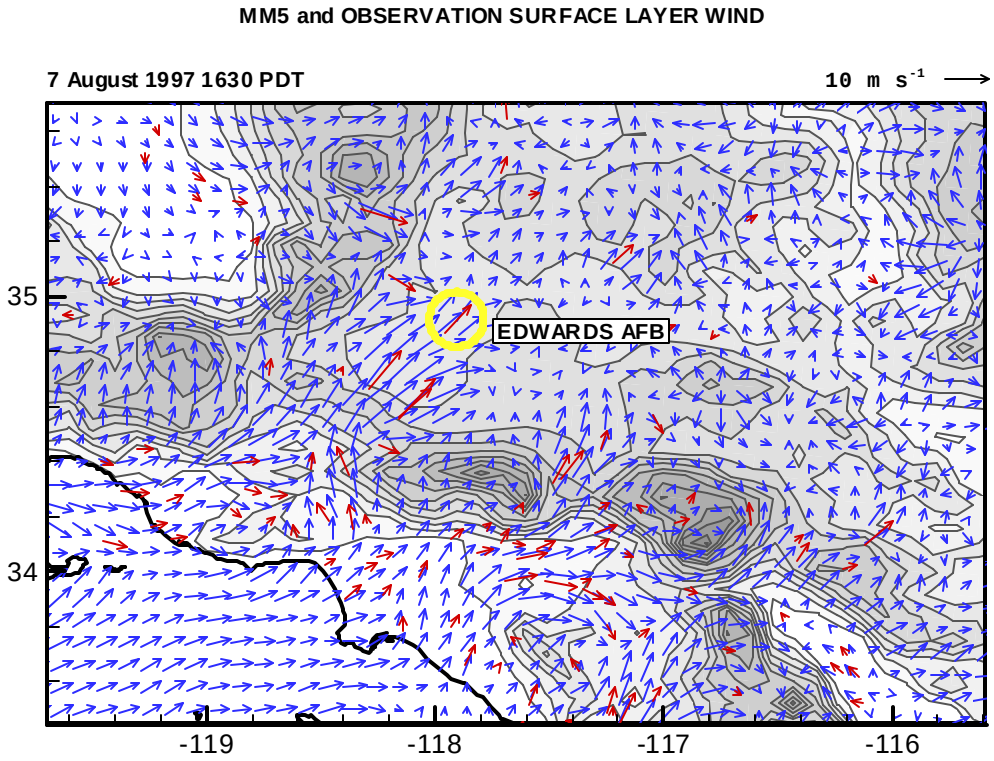

Figure 2-13. Streamlines for Transport of Pollutants from Los Angeles and Kern County

2.4.2 Makua Military Reservation. The U.S. Army completed a Supplemental Environmental Assessment (SEA) after several wildfires were started by training exercises outside the firebreaks in 1998, which threatened several endangered species and cultural sites. The Army suspended live-fire training following the 1998 wildfires pending the completion of the SEA. In December 2000, the Army released a draft SEA and Finding of No Significant Impact (FONSI) for public comment. A local citizens group (Malama Makua) filed suit saying the SEA analyses were inadequate and asked for an injunction preventing the Army from resuming live-fire training. The Army revised the SEA based on public input and issued the SEA and final FONSI in May 2001.

Three days later the federal court scheduled a hearing for July 2001 to consider the requests made in the lawsuit. The lawsuit filed by local activists sought to block the Army from using a combined arms assault course in Makua Valley pending completion of a more comprehensive Environmental Impact Statement (EIS). The Army countered that the SEA addressed all reasonable alternatives and evaluated all potential impacts. In addition, an EIS would take two to three years and cost several million dollars. The Makua course had been shut down for nearly three years because of the suit.

The September 11 terrorist attacks prompted both sides to settle quickly. Under a 04 October 2002 settlement brokered between Earthjustice Legal Defense Fund and the Army, the Army is allowed to train in the valley as long as it completes an EIS within three years. In return, Malama Makua was granted limited visitation privileges each month and will be allowed to have its members observe what the Army does in the valley. Under the terms of the agreement, the Army can conduct 16 company-size live-fire exercises over the next year, followed by 9 the following year and 12 the third year. However if the EIS is not completed by the end of the third year, no additional live-fire trainings can occur at Makua until the EIS and Record of Decision are complete. Makua is the only location on Oahu with live-fire capability above small arms. This means that to conduct live-fire training, units will have to deploy by sea and air to the Pohakuloa Training Area on the Big Island, 250 miles away. Although training events are regularly scheduled at Pohakuloa, conducting additional training cycles there will drastically increase costs and the time soldiers spend away from families when compared to completing the same training at Makua.

2.4.3 Advanced Deployable System Testing. The Advanced Deployable System (ADS) is a passive acoustic undersea surveillance system. The program is sponsored by the CNO and is managed by the Space and Naval Warfare Systems Command (SPAWAR). In 1998, the program completed an EA/Overseas Environmental Assessment (OEA) to conduct operational testing off the coast of southern California. The EA resulted in a FONSI with required mitigation measures. Trenching for cables going ashore could not occur during the plover nesting season, which runs March 1st through September 15th. This limited trenching activities to 4½ months of the year.

In order to test the passive acoustics, a towed sound source was used. Marine mammal watches were conducted for continuous sound sources transmissions. All watches began a minimum of 20 minutes before the start and continued throughout the test. A ship's watch was conducted at all times for tests less than 140 decibels (dB) (ref 1 µPa-m). A dedicated watch was conducted for tests greater than 140 dB (ref 1 µPa-m). The program had wanted to conduct night testing operations. However, due to limitations in visibility for the marine mammal watch, continuous sound source transmissions between 140 and 170 dB (ref 1 µPa-m) were conducted

only during daylight hours and when visibility was not limited by weather conditions. A dedicated watch consisted of two personnel trained in marine mammal identification whose only duty during testing events was the marine mammal watch. This required extra personnel on board ship during all testing events. A total of eight trips for testing were required with each trip lasting 3-10 days. Each trip had a mix of testing greater and less than 140 dB (ref 1 µPa-m) so personnel were required to be on board for the whole trip. This increased costs of the testing associated with labor and travel costs of the associated personnel. Operations were curtailed if marine mammals entered a preestablished zone, which varied depending on the decibels the sound source was operating. Costs were also increased when marine animals entered the zone, and were dependent on the amount of time they stayed.

3.0 CURRENT TECHNOLOGY: ISSUES RELATING TO DoD AND NAVY RANGE SUSTAINABILITY

3.1 General

The Navy has identified several key issues relating to sustainable ranges, with specific concerns being endangered species management, on- and off-range munitions constituent management, protected marine resource management, air pollution management, noise pollution management, and finally overall range facility management. This section describes the current state of applicable technology with respect to the major environmental concerns facing range managers, classified under the broad categories identified by the SROC.

Reviewed will be a brief background of the issue and how it pertains to Navy and Marine Corps ranges, discussion of applicable regulatory drivers, descriptions of technologies used to address these issues and where they may be applicable by specific range(s), and references to other in-depth sources of information.

3.2 Current Practices for Endangered Species Management

The ESA requires the Navy and Marine Corps to protect TES on and around training ranges, OPAREAs, and bases. The management of protected species has been a growing encroachment issue impacting operational use of Navy and Marine Corps ranges. In recent years the protection of endangered species, threatened species, and protected habitat has added new complexities to sustainable range management and has been hampering realistic training due to seasonal and area restrictions.

The DoD manages 25 million acres in the United States, providing habitat for more than 300 species listed as either threatened or endangered (Table 3-1). Presently, there are more than 180 TES on approximately 300 Navy and Marine Corps ranges and OPAREAs. Management of TES will continue to be a challenge based on several reasons:

- Land surrounding military installations and ranges has and will continue to be developed
- Pressure will continue to be exerted on federal lands and on DoD to shoulder an increasing share of the responsibility to protect dwindling habitats and species

Table 3-1. The Number of Endangered Species and Critical Habitat within the United States

Number of species of animals listed as threatened and endangered	514
Number of species of plants listed as threatened and endangered	744
Number of listed species with critical habitat	440
Number of plant and animal species proposed for listing as threatened and endangered	27

Source: USFWS (March, 2004).

- New marine resources such as marine protected areas and sanctuaries have the potential to limit at-sea operating areas for testing and training
- The number of species requiring protection will probably increase
- Interpretations of the applicability of legal and environmental compliance requirements will expand
- As weapon systems become more sophisticated, demands on testing and training ranges will increase.

Table 3-2 provides a limited summary of protective measures that the Navy and Marine Corps have undertaken to protect TES both on and off their lands.

Every Navy and Marine Corps installation has management responsibilities of natural resources and through the Sikes Act, every DoD installation is required to have an INRMP. The successful passing of several parts of the Range and Readiness Preservation Initiative has allowed INRMPs to be utilized for managing TES on DoD lands without the future critical habitat designations. This change will not roll back existing critical habitat designation, nor will it alter the requirements to consult with the USFWS.

While committed to conserving the natural resources on their lands, the Navy and Marine Corps operations have been and will continue to be restricted because of the presence of TES. A few examples follow:

- Amphibious training and test and evaluation exercises at Marine Corps Base Camp Pendleton have been restricted because of Western snowy plovers, California least terns, and fairy shrimp.
- Naval exercises at San Clemente Island have been restricted because of the recovery of the loggerhead shrike.
- Navy Sea, Air, and Land (SEAL) teams use of simulated ammunition and some other munitions are prohibited because of California least tern and Western snowy plover.
- Scheduling of range use has been impacted for reasons ranging from the presence of Sonoran pronghorn to shrike breeding season and migratory whales.

To balance the needs for sailors and marines to "train as they fight" and to protect TES, the Navy/Marine Corps is researching new processes/models that would provide more efficient management of their natural resources.

3.3 Munitions Constituents

The Navy has identified more than 25 MCs and their related daughter products from fired ordnances. The behavior of the parent compounds (2,4,6-trinitrotoluene [TNT] primarily and RDX/HMX to a lesser extent, as well as their daughter products) when released in the marine environment is beginning to be understood. The consequence of a lack of understanding of the

Table 3-2. Navy ESA Protective Measures

Navy/Marine Corps Installation	Species and Federal Status	Protective Measures
Navy	Green Sea Turtle Threatened	The Navy participates in a study to track the migration of the green sea turtle. The turtle shells are fitted with satellite transmitters, allowing scientists to track migration patterns.
Naval Submarine Base Kings Bay, GA	West Indian Manatee Endangered	After a Navy tugboat accidentally hit a female manatee and her calf swimming near Kings Bay in 1990, the Navy initiated a project to design propeller guards for its tugboats. Similar guards have now been installed on all tugs and other small vessels in the bay. Additionally, places where the manatees are known to congregate have been declared as no-entry areas, speed limits have been posted, and the Navy has begun a manatee watch program to monitor the animals.
Naval Activities Marianas	Tinian Monarch Threatened	By removing cattle and replanting trees, the Navy downlisted this bird's status from endangered to threatened. Today it has a population of more than 57,000 and has been proposed for full delisting.
Naval Amphibious Base, CA	California Least Tern Endangered	The Navy and the USFWS are implementing a Navy-initiated agreement, which helps both agencies achieve individual program goals and, at the same time, provides enhanced management for the tern. Each year, the Navy provides a single list of in-water construction projects planned for piers and dredging in San Diego Bay, which the USFWS reviews for impact to the terns. Together the agencies plan specific management goals for least tern nesting colonies on three Navy bases located along the San Diego Bay, as well as special projects which the Navy performs to benefit the terns. The Navy provides centrally managed funds for the tern management and projects, rather than tying piecemeal mitigations to small projects.
Marine Corps Air Station, Miramar, CA	Vernal Pools Critical Habitat	Protects 80% of the remaining vernal pools in San Diego County. These vernal pools are significant because they are home to the endangered San Diego mesa mint, button celery, and San Diego fairy shrimp.
Seal Beach Naval Weapons Station, CA	Light-footed Clapper Rail Endangered	Seal Beach Naval Weapons Station built 30 new artificial nesting platforms to increase populations of the endangered light-footed clapper rail.
Marine Corps Air Station Yuma, AZ	Sonoran Pronghorn Endangered	Partnering with the Air Force on the Barry M. Goldwater Range, the Marine Corps is taking a comprehensive approach to planning and implementing management tools that promote Sonoran Desert ecoregional biodiversity.
CINCLANTFLT Jacksonville, FL	Northern Right Whale Endangered	Critical Northern right whale (NRW) calving habitat in OPAREAs of the southeastern U.S. are mandated to be extensively monitored, and have necessitated formal year-round and seasonal restrictions on certain at-sea training.

nature and extent of MCs is the inability to perform human health and ecological exposure estimates. Unknown, assumed, and limited information for characterization, modeling, and risk assessment could be replaced with very conservative values that inflate the cleanup requirements if the Navy finds itself implementing expensive remediation technology, monitoring programs, and corrective actions.

3.3.1 Characterization. The ability to characterize, assess, and predict potential munitions constituent (MC) source loading and distribution has significant implications for DoD and Navy range sustainability initiatives. Source characterization is the term used to describe the type and amount of a contaminant introduced into the environment as part of an exposure pathway requiring the assessment of risk to human health and/or the environment. The Army characterizes ranges under the Army Environmental Quality Technology Program to determine environmental properties, fate, and transport of MCs in freshwater and land systems. In addition, SERDP in FY2001 began funding similar research on land ranges assessment in CP-1155, Distribution and Fate of Energetics on Test and Training Range.

Leveraging both Army environmental and SERDP funding, the U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC), has been characterizing contamination at firing points and impacts areas at several Army and Canadian Department of National Defense ranges. Extensive methodology has been developed for these studies using approved EPA detection methods as well as new detection technologies. Based on results from past efforts, the drive for new land MC detection techniques was elegantly summarized by Hewitt (2002), who stated that "The ability to quickly characterize the spatial distribution of NG (nitroglycerin) and other targeted explosive or propellant residues in soil is difficult at most military training facilities because of their vast sizes (tens of thousands of acres) and remoteness. A confounding factor for active training or testing ranges is that they are continuously being altered physically and chemically. Because of these factors it is prudent to use on-site analysis and dynamic sampling plans for characterization." Similar characterization studies at Navy and Marine Corp ranges have been more limited.

Currently, there are two EPA-approved SW-846 laboratory methods for characterizing explosives constituents in soil. Promulgated in 1994, SW-846 Method 8330 can detect 14 target analytes including TNT, RDX, HMX, tetryl, manufacturing impurities, degradation products of TNT, NG, and PETN, and some RDX degradation products. Method 8330 is a high performance liquid chromatography–ultraviolet (HPLC-UV) method and has been the industry standard for 10 years (T. Jenkins, ERDC-CRREL, *personal communication*). A second 1998 draft procedure is SW-846 Method 8095 (EPA, 1999a), which is a gas chromatography-electron capture (GC-EC) method. Method 8095 has 16 target analytes, including the original 14 analytes from Method 8330 plus NG, PETN, and 3,5-dinitroaniline (3,5-DNA). Detection limits for Method 8095 can be two to three orders of magnitude lower than Method 8330 (Thiboutot et al, 2002).

In addition to traditional laboratory based detection techniques, there are also two EPA approved methods for on-site analysis for TNT and RDX, colorimetric SW-846 Methods 8515 and 8510, which also can be used to detect other nitroaromatics, nitramines, nitrate esters, or groups of these compounds (T. Jenkins, ERDC-CRREL, *personal communication*; Hewitt, 2002; Hewitt and Jenkins, 1999). Other less-documented EPA methods include immunoassay techniques (EPA, 1996a, 1996b).

Finally, ERDC has been developing and validating a new field portable detection system called gas chromatograph thermionic ionization detector (GC-TID), which is sensitive to nitro function groups common to military explosive compositions. ERDC has demonstrated that results from GC-TID for TNT, RDX, 2,4-dinitrotoluene (2,4-DNT), and other explosives are very comparable to HPLC (Method 8330) and CG-ECD (Method 8095) (Hewitt, 2002).

Perchlorate is a good example of the difficulty developing an approved analytical method. The ability to detect perchlorate to 4 µg/L arrived in 1997. However, there still is no approved method for subsurface applications, and debate continues, even as the detection level drops to the part per trillion.

3.3.2 Fate and Transport. There are more than 200 risk assessment models of various types for potential application to ranges with releases of MCs. The models have been developed over the last couple of decades and are used extensively today. Other than a few exceptions (e.g., ARAMS), the DoD will not likely need to develop new models or modeling frameworks. The Army is working on comprehensive modeling techniques to assist in land-based munitions constituent risk determinations. The ARAMS is being developed by the Army Fate and Effects Research Program as a comprehensive system employing the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) to perform human and ecological risk assessment for a variety of sources including target ranges.

> FRAMES was developed by the Department of Energy Pacific Northwest National Laboratory (DOE-PNL) in cooperation with the U.S. Environmental Protection Agency (USEPA) by Battelle Memorial Institute and is consistent with USEPA guidance with regard to conducting site risk assessments (Brannon et al., 2000).

Additionally, the Navy is investing in an effort to modify ARAMS to support Risk Assessments in the Marine environment for munitions constituent compounds.

Again, the ability to use environmental risk assessments or fate and transport models currently is problematic because of the difficulty in accurately characterizing sites because of limited information on transport parameters for MCs (e.g., K_{ow}), and limited model evaluation and application at operational ranges. SERDP recognized some of these data gaps and currently has a FY05 Statements of Need to address the requirement for better land and water transport parameters (CPSON-05-01 Characterization and Fate of the Source Term of Energetic Compounds in Aquatic Environments; CPSON-05-02 Range Environmental Fate and Transport Exposure Assessment for Energetic Materials).

3.3.3 Perchlorate

3.3.3.1 Background. Perchlorate originates as a chemical found in the environment in the solid salts of ammonium, potassium, or sodium perchlorate. The perchlorate anion is quite soluble in water. The resultant anion (ClO_4^-) is very mobile in aqueous systems. It can persist for many decades under typical groundwater and surface water conditions because of its resistance to react with other available constituents.

Ammonium perchlorate is manufactured for use as the oxidizer component and primary ingredient in solid propellant for rockets, missiles, fireworks, and some munitions. Large-scale production began in the United States in the mid-1940s. Because of its documented shelf life, it

must be periodically washed out of the country's missile and rocket inventory and replaced with a fresh supply. Thus, large volumes of the compound have been disposed of since the 1940s.

Perchlorate is of concern because of (1) potential health effects at low concentrations; (2) the possibility that perchlorate may be widespread in the environment; (3) the expense of removing perchlorate from water and soil; and (4) the effects that perchlorate may have on ecosystems.

3.3.3.2 DoD Policy. On September 29, 2003, DoD released its *Interim Policy on Perchlorate Sampling*. It states that DoD components shall continue to consolidate existing perchlorate occurrence data, and shall sample any previously unexamined sites where a perchlorate release is suspected because of DoD activities and where a complete human exposure pathway is likely to exist. It also states that DoD components shall establish and maintain databases containing the information described below. The September 29, 2003 policy supercedes the DoD November 13, 2002 memorandum *Perchlorate Assessment Policy*. There are specific sections of the policy that relate to the SDWA's Unregulated Contaminant Monitoring Rule (UCMR), the CWA, Defense Environmental Restoration Program sites, and Operational Ranges. Each of the sections was required to submit and maintain a database of results of any sampling. This discussion highlights only the requirements under the SDWA, CWA, Environmental Restoration Program, and Operational Ranges.

SDWA: The UCMR (40 CFR Parts 9,141, 142) mandates that all community and non-transient, noncommunity water systems serving more than 10,000 persons, as well as smaller systems selected by the EPA, monitor for specific contaminants, including perchlorate. Some military installations are subject to the UCMR and, therefore, should be testing for the presence of perchlorate and reporting the results to EPA and state regulators, as appropriate.

CWA: Several states require some military installations to monitor for perchlorate under the CWA NPDES permit program. Sampling and reporting in compliance with an NPDES permit is a Class 1 compliance-funding requirement. Each DoD component shall establish and maintain a database of sampling data (by discharge point) for those permitted discharges that have a perchlorate reporting requirement in their NPDES permit, or other state requirement to monitor for perchlorate.

Environmental Restoration: DoD components shall continue to consolidate existing perchlorate occurrence data at DoD active or closed installations, nonoperational ranges, and Formerly Utilized Defense Sites (FUDSs). For these categories, DoD Components shall also program resources and sample for the presence of perchlorate at any previously unexamined site where there is a reasonable basis to suspect that a release has occurred as a result of DoD activities and where a complete human exposure pathway is likely to exist.

Operational Ranges: Assessing operational ranges for the potential for off-range migration of perchlorate is consistent with the MAP and the Defense Planning Guidance (DPG) requirements. The DPG requires the secretaries of the Military Departments to

assess potential hazards from off-range migration of MCs. This policy memorandum requires the military departments to include perchlorate in future range assessments.

3.3.3.3 Regulatory Considerations. There currently is no federal National Primary Drinking Water Regulation for perchlorate. It is on the EPA's SDWA Contaminant Candidate List, but before a determination to regulate can be made, data gaps must be filled regarding occurrence, health effects, treatment technologies, and analytical methods. Finding these answers for perchlorate is a very high priority. The data generated by the UCMR, which includes all of the compounds on the contaminant candidate list, will be used to evaluate and prioritize contaminants on the Drinking Water Contaminant Candidate List.

The EPA established a provisional reference dose (RfD) range based on assessments of existing information in 1992 and revised in 1995. By applying the standard default body weight (70 kg) and water consumption level (2 L/day), the resulting provisional cleanup or action levels would range from 4-18 parts per billion (ppb). This level currently represents agency policy, which was reaffirmed in January 2003.

The current EPA draft human health risk assessment was released in 2002 and has a revised oral human health risk benchmark of 0.00003 mg/kg-day. By applying the standard default body weight (70 kg) and water consumption (2 L/day) values, a drinking water equivalent level (DWEL) would be calculated at 1 ppb. It is important to note that this assessment is in draft form and does not represent agency policy.

Currently, a committee of the National Academies of Science is assessing the adverse health effects resulting from ingestion of perchlorate from clinical, toxicological, medical, and public health perspectives. The committee is critically evaluating the scientific literature, including both human and animal data, and will assess the key studies underlying EPA's 2002 *Draft Toxicological Review and Risk Characterization for Perchlorate* in terms of quality, reliability, and relevance, to draw conclusions about the health implications of exposure to low levels of perchlorate in drinking water.

Based on the above review, the National Academies of Science committee will determine whether EPA's findings in its 2002 *Draft Toxicological Review and Risk Characterization for Perchlorate* are consistent with the current scientific evidence. The committee will also suggest specific scientific research that could reduce the uncertainty in the current understanding of human health effects associated with low-level perchlorate ingestion. The committee report is expected to be issued in September 2004.

Following the establishment of a final harmonized oral human health risk benchmark for perchlorate, the EPA will develop a drinking water health advisory.

Certain states have begun the process of regulating perchlorate. In 1997, California established a provisional action level of 18 ppb for perchlorate in public water supplies. In January 1999, the California Department of Health Services (CA DHS) adopted a regulation identifying perchlorate as an unregulated chemical for which monitoring is required. Certain drinking water systems are required to sample their drinking water sources for perchlorate. The reported perchlorate detections in public water systems and drinking water sources in California, as of June 3, 2002, are 11% of public water systems and 6.6% of drinking water sources. This number is about twice the impact that methyl-*tertiary* butyl ether (MTBE) has had to date in the state.

In January 2002, CA DHS changed its provisional action level for perchlorate to 4 ppb. This change was prompted by EPA's January 2002 release of the *Perchlorate Environmental*

Contamination: Toxicology Review and Risk Characterization. This level is still, however, based on the 1995 peer-reviewed data, which allowed for a level between 4 and 18 ppb. An action level is an unenforceable notification level that requires drinking water systems exceeding this level in potable water to notify their local governing body. The CA DHS then recommends public notification. Some drinking water purveyors in the state have stopped serving water over the action level for fear of potential litigation. Surface water (Colorado River) is not included in the reporting requirements or recommendations.

In March 2002, the California EPA Office of Environmental Health Hazard Assessment (OEHHA) *Draft Public Health Goal (PHG) for Perchlorate* was released for public comment. The PHG document relies heavily upon the latest EPA assessment for perchlorate for the science to generate the numbers for the PHG. Some of the key differences are that the PHG is based upon the use of human data to generate the PHG, the use of a relative source contribution factor (0.6), and a lower uncertainty factor of 30. Their latest assessment from December 2002 results in a PHG range from 2 to 6 ppb.

The schedule for the establishment of a PHG in California includes a number of events. OEHHA's establishment of a PHG required a public meeting held on April 29, 2002. The purpose of the meeting was to allow the public to comment on the PHG. Following the meeting, OEHHA was to revise the document as appropriate, and make it available for a 30-day public review and scientific comment period. This second review and comment period was announced in December 2002, published in the California Regulatory Notice Register, and posted on the OEHHA Web site. The responses to the major comments from the public at the workshop and during the two public review and scientific comment periods, as well as from peer reviewers at the University of California system and state and federal agencies, also will be available on the OEHHA Web site. A final PHG is expected in 2004. A maximum contaminant level (MCL) is expected in 2004.

In October 2001, Texas revised its interim action level for perchlorate in drinking water from 22 ppb to 4 ppb. The Texas Risk Reduction Program (TRRP) residential groundwater cleanup standard also is 4 µg/L. The TRRP commercial/industrial groundwater cleanup standard is now 7 µg/L. The Risk Reduction Rule (RRR) residential groundwater cleanup standard is 4 µg/L. The RRR commercial/industrial groundwater cleanup standard is 10 µg/L.

The Massachusetts Department of Environmental Protection (MA DEP) completed in January 2004 a technical assessment of the toxicity and health effects of perchlorate that was released in May 2004. In that document, MA DEP identified a chronic oral RfD of 3×10^{-5} mg/kg-d. This draft RfD would be associated with a drinking water exposure limit of 1 µg/L using standard exposure assumptions and methodologies used to derive drinking water guidance.

3.3.3.4 Sampling and Analysis of Perchlorate. The *Draft Sampling and Testing for Perchlorate at DoD Installations, Interim Guidance* was released on 21 January 2004. This document provides interim guidance developed by the DoD Environmental Data Quality Workgroup (EDQW) designed to help DoD Installations comply with the 29 September 2003 *DoD Interim Policy on Perchlorate Sampling*.

Sampling requirements for the SDWA and CWA use EPA Method 314.0 *Determination of Perchlorate in Drinking Water Using Ion Chromatograph* (EPA, 1999b). This method is the only EPA-approved method for determining perchlorate in drinking water under the UCMR. The use of Method 314.0 may also be mandated in NPDES permits. Method 314.0, as currently

written, however, is not reliable for determining perchlorate in environmental matrices other than drinking water, nor is it reliable for determining perchlorate concentrations below 4 ppb in drinking water. If perchlorate is detected using this method at concentrations above the regulatory or permit-specified limits, then results must be verified by alternate, definitive, performance-based methods, such as those employing mass spectrometry (MS) technology. If a regulatory agency requests a method reporting limit (MRL) below 4 ppb, then that agency should identify (or agree to the use of) an acceptable alternate method or modified Method 314.0 that meets the quality assurance/quality control (QA/QC) criteria defined in the interim sampling guidance.

When a determination is made to conduct perchlorate sampling and testing for Environmental Restoration or Range Assessment activities, installations must prepare a site-specific Quality Assurance Project Plan (QAPP) or Sampling and Analysis Plan (SAP). The QAPP/SAP must address the regulatory basis and/or reasons for suspecting perchlorate contamination, potential human-health receptors and migration pathways, sampling locations and rationales, analytical methods, action levels, and data reporting requirements. The QAPP/SAP must also address all QA/QC considerations contained in this policy.

When conducting sampling and testing for perchlorate in groundwater, soil, sediments, or other environmental matrices, installations shall (1) document the applicable regulatory limit or action level (i.e., concentration of concern) for each matrix being sampled, and (2) identify analytical methods that can achieve an MRL, in the matrix of concern, at or below the specified regulatory limit or action level. If sampling and testing activities have been requested by a regulatory agency, or are subject to regulatory oversight, then installations should secure regulatory authority approval for use of the method. The collection of split samples is strongly recommended (i.e., where a portion of each sample is sent to a second laboratory).

In most cases, Method 314.0 will not be suitable for use in analyzing environmental samples under environmental restoration or range assessment activities, and either a modified Method 314.0 or alternate method should be used. If Method 314.0 or its modifications are used, then any results detected above the regulatory limit or action limit must be confirmed using definitive analytical methods (e.g., those employing MS).

Regardless of the method used, method QA/QC requirements, including calibration procedures and procedures for documenting the MRL, must be equivalent to or more stringent than those specified in Method 314.0. Each laboratory must document an MRL in the specific matrix of concern that is at or below the regulator-specified action level. The MRL cannot be lower than the lowest calibration standard. Ideally, the action level should be at least three times (3x) the MRL. Laboratories must provide data to demonstrate that laboratory glassware, reagents, and solutions are free from contamination by perchlorate. [Note: a large commercial laboratory recently reported perchlorate contamination in some detergents used to clean laboratory glassware.]

All laboratories selected to perform perchlorate analysis shall comply with the current *DoD Quality Systems Manual for Environmental Laboratories* (QSM) [DoD, 2000].

3.3.3.5 Treatment Technologies. Because perchlorate was discovered in water supplies in California, Nevada, and Arizona, much progress has been made in developing treatment methods to remove perchlorate from water. More than 65 perchlorate treatment technology projects have been funded. Agencies funding this research include the American Waterworks Association Research Foundation, DoD's SERDP, DoD's Environmental Security Technology Certification Program (ESTCP), the National Science Foundation, several universities, water utilities, and

DoD activities. Most of the attention has been directed at two technologies: biological treatment and ion exchange.

In the biological treatment process, microbes destroy perchlorate by converting the perchlorate ion to oxygen and chloride. In most cases, nutrients must be added to sustain the microbes. A full-scale system at a Superfund Site in Northern California, where perchlorate concentrations exceed 1,000 ppb, has been operating for a number of years.

An ex situ biological process has been used to treat perchlorate-containing wastewaters resulting from the manufacture and maintenance of rocket motors, where perchlorate concentrations may exceed 5,000,000 ppb. This continuously stirred tank reactor has been operating for several years at the Thiokol plant near Brigham City, Utah, and received a patent in 1994. Smaller, remediation-scale systems have been in place at the Longhorn Army Ammunition Plant and at the Naval Weapons Industrial Reserve Plant, McGregor, both in Texas, for the last few years. These fluidized-bed biological systems have influent concentrations between 1,000 and 50,000 ppb and have consistently had effluent levels at the EPA Method 314 reporting limit. The ex situ biological treatment method is capable of producing potable water and has recently been approved for drinking water applications in California, although it has not been installed on any drinking water wells to date. Biological treatment methods are new to drinking water utilities, but biologically active filters have been used in drinking water treatment for decades to help remove particles and biodegradable organic matter. The approved treatment train relies on biological treatment for primary removal of perchlorate, and includes an intensive sampling program to determine process parameters.

The advantages of bioreactors include a relatively small and compact size; ease of operation; ability to be inserted as an add-on treatment device into existing pump-and-treat systems; produce minimal biosludge; and relatively cost-effective, e.g., low capital, operation, and maintenance costs. The disadvantages of bioreactors include: they are a long-term pump-and-treat technology; require careful control of reactor vessel environmental conditions, such as temperature, pH, oxygen content, and nutrient loading; typically require regular nutrient addition because the dilute nature of contaminated groundwater may not support an adequate microbial population density; the discharge of treated water may still be regulated and require additional treatment; and access to an uninterrupted power supply is critical to the operation of a bioreactor system.

In situ bioremediation also has been pilot tested at the Aerojet site, with promising results. Aerojet also has demonstrated a biobarrier approach at its site with help from SERDP. Reportedly, the perchlorate concentration has been reduced to the reporting limit of 4 ppb.

Research studies sponsored by SERDP have identified critical factors that influence the effectiveness of the technology. For example, more than 30 different strains of perchlorate-reducing bacteria have been isolated from diverse environments and these bacteria appear to be ubiquitous. Perchlorate typically can be degraded to chloride and water by the microorganisms in less than 30 days in laboratory experiments. The presence of oxygen, nitrate, and low pH are inhibitory of perchlorate reduction by these bacteria; and most perchlorate-respiring microorganisms are capable of living under varying environmental conditions. Pilot results at the Naval Surface Warfare Center Indian Head have reduced the perchlorate concentration to the reporting limit of 4 ppb. Barrier walls using biological treatment have been implemented at full scale at the Naval Weapons Industrial Reserve Plant in McGregor, Texas. This site also has implemented the injection of carbon sources to form a biobarrier. ESTCP has funded, and will be performing, three demonstrations of in situ perchlorate bioremediation over the next year.

The advantages of in situ bioremediation include treatment of the groundwater without pumping to the surface; potentially more cost-effective than ex situ pump-and-treat systems; biodegrades perchlorate relatively quickly; works even at low concentrations of perchlorate; naturally occurring perchlorate-reducing microorganisms exist in the environment; carbon sources demonstrated to date are relatively inexpensive; may treat other soil or groundwater contaminants simultaneously with perchlorate; can be used to treat soil hot spots; requires minimal aboveground structures; and the land above ground is usable during treatment period. The disadvantages of in situ bioremediation of perchlorate include the requirement for drilling to deliver the carbon source; the targeted groundwater must be within reasonable depth limits for cost-effectiveness; the potential for less certain, nonuniform treatment results from variability in aquifer, climate, weather, and soil characteristics; the requirement of careful control of site-specific environmental characteristics (e.g. ,oxygen content, pH) to maintain optimal treatment conditions; the potential secondary impacts to water quality; and the capture and reinjection of treated water may be required.

Phytoremediation is a treatment technology that uses natural plant processes and microorganisms associated with the root system to remove, contain, or degrade environmental contaminants in soil, sediment, and water. Bench- and pilot-scale tests conducted at Longhorn Army Ammunition Plant have confirmed that perchlorate can be degraded through phytoremediation. Experimental results suggest that the two most important phytoremediation processes for perchlorate involve the uptake and subsequent phytodegradation of the chemical in branches and leaves, and rhizodegradation.

The advantages of phytoremediation include a passive, minimal environmental disturbance treatment process; the treatment of soils using this technology can prevent further groundwater contamination; the treatment of co-contaminants; the potential low cost (although validated cost and performance data are generally still lacking); and a reduction in the generation of secondary wastes. The disadvantages of phytoremediation include a lack of data on overall processing rates, endpoints, and cost data; a treatment depth limitation; regulatory unfamiliarity; potentially slower than competing remedial technologies; and the potential cross-media transfer of contamination (e.g., soil and/or water to plant tissues).

The second of the two major perchlorate-removal technologies receiving the most attention is ion exchange. In ion exchange the perchlorate ion is replaced by chloride, a chemically similar but nontoxic ion. Ion exchange processes have been used in homes and businesses for water softening for decades. Bench, pilot, and full-scale studies have demonstrated that ion exchange systems can reliably reduce perchlorate concentrations and are approved for drinking water use in California.

The DoD has been investigating the use of ion exchange to treat perchlorate-contaminated groundwater at Edwards AFB, California. Edwards AFB has been field-testing a new class of anion exchange resins in a conventional fixed-bed ion exchange system. The bifunctional resins originally were developed by scientists at the Department of Energy Oak Ridge National Laboratory. The pilot demonstration has treated more than 9 million gallons of water and removed 32 lb of perchlorate. A type II resin also has been used on an interim basis at the Naval Weapons Industrial Reserve Plant, McGregor. Ion exchange systems produce a concentrated brine that requires disposal and/or further treatment, or the resins are nonregenerable and must be disposed of. Research is underway to try to identify methods of reducing the volume of perchlorate-contaminated brines to reduce the high cost of disposal. Edwards AFB will be evaluating a novel destruction technique.

The advantages of ion exchange include a proven ability to remove perchlorate to below 4 ppb: a fast reaction and simple operation; can be operated at a high flowrate; regulatory acceptance; and the cost-effectiveness is improving rapidly with technical innovation. The disadvantages of ion exchange include high levels of suspended solids in wastewater may cause clogging of nonselective resins; waste brine from regeneration step requires treatment and disposal; spent nonselective resins may require frequent replacement and disposal; competitive uptake by other anions may limit the effectiveness of nonselective exchange resins; and effectiveness of treatment is strongly influenced by water chemistry of a site (e.g., the presence of competing anions and the pH of the water source).

Perchlorate releases into the environment also can impact soil. Treatment of the soil has been performed by using microbes to degrade the perchlorate in the soil. Soil biotreatment alternatives, can be either ex situ (i.e., above ground) or in situ (i.e., in place, in ground), and include biotreatment cells, soil piles, and prepared treatment beds. At the NWIRP McGregor, perchlorate-contaminated site soil was transported to an onsite, plastic-lined engineered treatment cell. Prior to placement in the cell, the soil was mixed with a carbon source, nitrogen and phosphorous fertilizer (micronutrients), soda ash (buffer), and water in quantities/ratios determined during the preliminary study. Additional water was added and the cell was covered with a plastic liner. After 6 months, soil was sampled at six random locations and analyzed for perchlorate. All six samples were below the target cleanup level. LHAAP laboratory tests on perchlorate-contaminated soil identified chicken manure, cow manure, and ethanol as suitable carbon sources for the enhancement of in situ bioremediation of perchlorate. These carbon sources were applied in a pilot-scale demonstration. After 10 months, complete removal of perchlorate was observed within 1 to 2 ft, with varied levels of reduction in the deeper layers. At the termination of the field study, the concentration of perchlorate in the wettest cells had decreased to nondetectable levels.

The advantages of soil biotreatment of perchlorate include a short-term technology that can be used to treat localized hot spots and source contribution zones; treatment maybe more cost-effective than conventional dig-haul-treat approaches; and relatively simple to implement. The disadvantages of soil biotreatment include ex situ treatment of contaminated soils may require significant excavation and manipulation; current research suggests that biological processes are most effective when the contaminant is within 18 inches of the surface; a static, nonmechanical treatment process may result in less uniform treatment than processes that involve periodic mixing; the potential for contamination downstream (e.g., *Escherichia coli* from manure or nitrates from nutrients); and the fact that site-specific climatic and hydrogeochemical conditions impact effectiveness.

3.4 Protected Marine Resources

3.4.1 Coral Reefs. The ability to characterize, assess, and monitor underwater benthic communities associated with DoD sites or activities is required in order to document compliance with promulgated national policy and to ensure that DoD operations do not lead to natural resource degradation, particularly with respect to coral reefs. E.O. 13089 "Protection of Coral Reefs" dated June 11, 1998 directs federal agencies including the DoD to study, restore, and conserve U.S. coral reefs. Specifically, E.O. 13089 directs federal agencies whose actions may affect U.S. coral reef ecosystems, to take the following steps: (1) Identify actions that may affect U.S. coral reef ecosystems; (2) utilize programs and authorities to protect and enhance the conditions of

such ecosystems; and (3) to the extent permitted by law, ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems. The DoD is a participant in the U.S. Coral Reef Task Force (CRTF) and through policy supports coral reef preservation and E.O. 13089. One of DoD's responsibilities as a CRTF member is to map and assess the coral reef ecosystems under its control.

SERDP issued a statement of need (SON) in FY02 (CSSON-03-02) that was directed toward the development of advanced technologies to assess DoD coral reef communities and the development of advanced technologies for fine-grained mapping and assessment of specific benthic areas. Subsequently, the solicition was awarded to the Institute of Marine and Coastal Sciences, Rutgers University. Their current effort relates to (1)the development of bio-optical techniques for rapid and nondestructive assessment of the viability and health of coral reef communities; (2) the development of submersible fluorosensors for permanent underwater monitoring stations and Remote Operated Vehicles; and (3) the collection of an extensive library of baseline data on physiological, biophysical, bio-optical and genetic diversity of coral reef communities near DoD installations in three major geographic areas (Program Guide, Partners in Environmental Technology Technical Symposium and Workshop; page 215; December, 2003; Washington, DC.)

The United States and host countries are concerned and actively involved with protecting marine resources. In response to the rapid deterioration of coral reefs worldwide, E.O. 13089 on Coral Reef Protection directs federal agencies to study, restore, and conserve U.S. coral reef ecosystems. It also established the CRTF, comprised of 11 federal agencies and the governors of 7 states, territories or commonwealths with responsibilities for coral reefs (see www.coralreef.gov). The CRTF was directed to oversee federal agency implementation of E.O. 13089 and to implement initiatives in the following areas: coral reef mapping and monitoring; research on causes of reef degradation; conservation, mitigation and restoration measures; and international cooperation strategies. In March 2000, the CRTF published *The National Action Plan to Conserve Coral Reefs*, a comprehensive document outlining goals, objectives, strategies, and priority actions to prevent the further decline of coral reefs. A major thrust in both the action plan developed under E.O. 13089 and the Strategy is a mapping and inventory initiative of all U.S. coral reef ecosystems. The assessment and monitoring initiative includes conducting rapid assessment and inventories, monitoring of coral, fish, and other resources, and evaluation of water and substrate quality. To implement DoD's responsibilities under the CRTF and comply with the Coral Reef Conservation Act of 2000 (CRCA), mapping and inventory information must be gathered on the military's coral reef resources. As a member of the CRTF, it is DoD's role and duty to conduct these activities. Moreover, DODI 4715.3, directs DoD to inventory biologically or geographically significant or sensitive natural resources. This information is also necessary for preparation of INRMPs required by the Sikes Act Improvement Amendments, 16 USC §670a-o.

NAVFAC has sponsored a Legacy-funded project to train Navy divers to assess coral reef conditions. Such activities are intended to supplement current diver mission requirements for construction and assessment of underwater facilities. Information from the assessment are be used to develop a guidance document entitled "Coral Reef Protection and Management Guidelines for DoD Vessels and Facilities." This document will outline best management practices for vessels and facilities that must operate near coral reefs so they can incorporate coral reef protection and stewardship practices in their operations. Below is a preliminary list of DoD

installations that were considered for testing and evaluating the proposed technologies developed under this project:

Navy

- Marine Corps Base Hawaii
- Naval Activities Guam
- Pacific Missile Range Facility (PMRF), Hawaii
- Naval Station, Pearl Harbor, Hawaii
- Naval Air Station, Barbers Point, Hawaii
- Naval Station Guantanamo Bay, Cuba
- Naval Station Roosevelt Roads, Puerto Rico
- NASD, EMA, and AFWTF, Vieques
- Naval Air Station, Key West FL
- White Beach, Okinawa, Japan
- Awase Transmitter Site, Okinawa, Japan
- Farallon de Medinilla
- Tinian
- Diego Garcia

3.5 Air Pollution

3.5.1 The Clean Air Act. Sources of air pollution that may affect air quality over or near Navy/Marine Corps test and training ranges are: open-burning/open-detonation (OB/OD), aircraft engine emissions, vehicle engine emissions, dust (PM_{10}) generated by vehicular operations, emissions from intentional burns (prescribed fire) to manage vegetation cover range and fire-fighting exercises, and sea-borne vessel operations. The CAA requires the EPA to establish standards and programs to protect air quality in the United States from these operations and has led to observed impacts on air quality for training and test operations at many ranges. The most serious range encroachment problems are from the regulation of opacity and from "conformity" requirements. Opacity measures the degradation of visibility due to the presence of air pollutants. It is an especially sensitive issue near parks and designated wilderness areas, and few national security exemptions exist for it.

The 'conformity rule' applies only to federal agencies. It applies to areas that have not attained or only recently attained the CAA's health-based standards called the NAAQS. The goal of 'conformity' is to ensure that air quality is not significantly degraded by federal agency plans and operations. Areas that do not meet NAAQS standards for criteria pollutants are called nonattainment areas and areas that have only recently met the standards are called maintenance areas. The 'conformity rule' requires federal agencies to analyze emissions from proposed projects or activities (e.g., the transfer of the home base of an aircraft squadron) and offset any potential emissions increases for nonattainment and maintenance areas by purchasing or trading for emission credits. The conformity rule prohibits federal agencies from going forward with a project or activity unless the additional air emissions that have been identified can be either offset or be accommodated by working with the state government to revise the state budget for them. A local factor that may come into play is that any offsets for emissions (or lack of them) can have an affect on commercial growth in the area.

All mobile and stationary source emissions must be evaluated in the conformity analysis. Although 'conformity' has had its greatest impact on planned changes in operations at 'activities,' this rule can hamper planned upgrades or new training approaches in nonattainment range areas, as well. It is a fundamental that cannot be overlooked in the long-range planning for ranges.

3.5.2 Pollutant Descriptions. The primary air pollutants (pollutants emitted directly from sources) of concern are: particulate matter (PM_{10}, and $PM_{2.5}$ – particulate matter less than 2.5 microns in diameter); NO_x; carbon monoxide, volatile organic compounds; and hazardous air pollutants (HAPs) in some cases. The primary gaseous species of NO_x and volatile organic hydrocarbons react in the atmosphere (in the presence of sunlight) to form secondary pollutants ozone, $PM_{2.5}$, and some other oxygenated species. HAPs are emitted as both gaseous species and as condensed (as particulates) species.

Particulate matter includes both solid and liquid particles suspended in the air. It is chemically and physically diverse and originates from a variety of human and natural activities. Particles less than 2.5 microns in diameter ($PM_{2.5}$) are referred to as fine particulate and generally pose the greatest health risk because they can penetrate more deeply into the lungs. PM_{10} comes from sources such as unpaved roads, crushing and grinding operations, and wind-blown dust. It is larger and much of it settles out of the atmosphere fairly quickly. $PM_{2.5}$ may be either directly emitted from a source as a primary particulate – usually a combustion source where it is composed largely of carbon and is a form of soot – or formed in the atmosphere by the chemical reaction of gaseous precursors to form what is called a secondary particulate. $PM_{2.5}$ is composed of sulfates, nitrates, and elemental and organic carbon, many of the latter being polyaromatic hydrocarbons, some of which are carcinogenic. Degradation of visibility in the atmosphere is due, mainly, to the accumulation of very fine particulate ($PM_{2.5}$) which does not rapidly settle from the atmosphere as does most of the PM_{10}.

3.5.3 $PM_{2.5}$. $PM_{2.5}$ is the newest air pollutant to be regulated by the EPA, and states are just now completing assessments of ambient $PM_{2.5}$ data that has been collected since 2001 to determine those regions (air basins or district boundaries) of the country that will be determined as nonattainment, attainment, or unclassifiable. EPA is scheduled to complete this process by December of 2004. It should be noted that an area can be classified nonattainment whether the sources of the $PM_{2.5}$ is located within the air district under consideration or whether the $PM_{2.5}$ is transported into that district from adjoining districts (the latter a frequent condition). In either case the military activity in the nonattainment area remains subject to the limitations imposed by a nonattainment classification (i.e., increased requirements caused by 'conformity' requirements).

$PM_{2.5}$ is essentially different from PM_{10} in that it is produced as a direct emission from combustion devices or is formed in the atmosphere from NO_x and hydrocarbons present there. Therefore high atmospheric concentrations of $PM_{2.5}$ are usually associated with large population and industrial centers – with the exception of some rural areas where smoke from wildfires is a problem. With this in mind nonattainment for $PM_{2.5}$ is not expected to be an issue in most areas of the country. Parts of central and southern California and areas near the metropolitan areas of St. Louis, Chicago, Pittsburgh, Philadelphia, Washington DC, and New York City will be the areas primarily affected. The south, south-east, mid-west, northwest, and far northeast, in accord with current reports, will be largely unaffected. Norfolk will be unaffected, but parts of

Maryland up near Washington will be. Navy operations in central California (e.g., Lemoore NAS) down through the Los Angeles area to San Diego will be affected by the $PM_{2.5}$ non-attainment classification, not because the military is a dominant source of $PM_{2.5}$ in those areas (overall, military contributions are relatively minor), but because the military is located in an area where population and industry have converged to create a $PM_{2.5}$ nonattainment condition. The Marine Corps Base at Twentynine Palms, interestingly, will probably not be classified as nonattainment as it is located in an air basin out of the central corridor of Southern California where most of the pollutant species are transported to and from the more metropolitan areas. $PM_{2.5}$ measurements made at Twentynine Palms over several years show that concentrations there are well below the nonattainment level, and the Navy and Marine Corps have negotiated with the State of California to be considered part of East Kern County (which is expected to be in compliance for $PM_{2.5}$) as opposed to part of West Kern County (which is expected to be out of compliance for $PM_{2.5}$).

3.5.4 Sources of Air Pollutants. Emissions can be from either stationary (not self-propelled, e.g., OB/OD) or mobile sources. Mobile sources include vehicles, nonroad equipment, marine engines and aircraft. To meet the NAAQS states may be required in their State Implementation Plans to institute emission controls on any or all emission sources. Although tactical vehicles are exempt from these controls, emissions from them must be taken into account in activity and range emission inventories and must be considered in 'conformity' analyses.

3.5.5 OB/OD. OB/OD takes place at both remote ranges and at ranges more proximate to base populations. Although much effort has been devoted to the characterization and control of emissions from OB/OD over the past decade, much remains to be learned in each of the areas of concern: characterization of emissions, control of emissions, and transport of emissions to adjoining areas. Emissions can be in a wide variety of chemical species produced during the OB/OD processes, gaseous and condensed. How the emission of these species can be controlled and how they react and are transformed in the atmosphere as they are transported from the OB/OD site to downwind locations is still being intensely investigated.

3.5.6 Aircraft Emissions. Characterization of emissions from aircraft is one of the foremost environmental problems for the Navy. Characterization of both gaseous and particulate emissions from the military's legacy aircraft has been continuous over the past two decades. Although the measurement of gaseous species can be accomplished using widely accepted procedures, measurement of particulate matter (PM) emissions has been accomplished by the EPA's Method 5, which is no longer accepted as being reliable. Rather, many of the complexities involved in the formation of PM in the jet engine exhaust plumes, and for which the Method 5 does not account, are being re-evaluated with the objectives of arriving at a new measurement approach that the EPA, Federal Aviation Administration (FAA), DoD, and the aircraft industry can embrace as being an acceptable replacement for the old Method 5. Several projects are under way to investigate these new proposed methods and others are being proposed. This issue is in a state of flux, and when resolved may require the re-measurement of PM emissions from legacy aircraft as well as measurement of emissions from the emerging new aircraft. As newer aircraft and engines, usually, have lower pollutant emission factors, it is in the Navy/Marine Corps interest to have the most up-to-date aircraft emission measurements possible.

Emission factors (e.g., lbs pollutant/1,000 lbs fuel consumed) are used to determine total aircraft emissions for entire activities for defined flight operations. These calculations are important in determining base emission inventories such as might be required for a conformity analysis and which, normally, considers aircraft emissions only up to the top of the atmospheric mixing layer (3,000 to 4,000 ft). Above that altitude air quality concerns are no longer, strictly, an issue. While statements have been made (and there does not seem to be data to the contrary) that indicate emissions from aircraft operating over test ranges will not produce an air quality problem, and while aircraft emissions over the home base are accounted for by base pollutant inventories and conformity analyses, these evaluations do not address emissions from aircraft flights to and from ranges or other emissions related to aircraft range operations. It can be said that these emissions may be small and inconsequential and are not regulated; however, this may not be the case. It is uncertain how these total aircraft emissions should be apportioned to the ranges, other related aircraft operating areas, and to their home bases (and affect the air quality in each place). As the technology for analyzing these emission problems becomes more sophisticated, this may be an issue that the Navy will have to face.

3.5.7 Other Sources. The Navy will probably be confronted in the near future with requirements to install emission control devices on some of its diesel engines – for both off- and on-road nontactical engines. Of course, emissions from these engines will not be expected to contribute significant emissions on ranges, and tactical engines are expected to remain exempt from any emission controls. Therefore the only range air quality concern originating from vehicle emissions might be from large, land-based exercises (such as at Twentynine Palms or Camp Pendleton) where the emissions generated from tactical engines could become excessive on the range and/or be transported into adjoining areas. Similarly, dust emissions (PM_{10}) generated by military operations may occur at more remote range locations so that although the effect of PM_{10} may be felt by personnel in training it will have less effect on nearby communities. Evaluation of the potential effect of this dust on adjoining areas must be evaluated for each specific area of interest. PM_{10} has been identified as a range sustainability issue by the Army. The contributions of sea-going Navy and Marine Corps vessels to range air quality issues is believed to be small, but this issue may require continued evaluation. Emissions from fire-fighting exercises are a continuing source of concern where different approaches have been evaluated without adequate resolution.

3.5.8 Air Quality Modeling. The determination of whether any of the above issues may contribute to deficiencies in air quality at military ranges may, in the final analysis, depend upon the capability of the Navy to effectively model that region, the chemical species and effects under consideration, and to project with sufficient accuracy the impact of given sources (i.e., whether OB/OD, aircraft, vehicle, PM_{10}, ship, or fire-fighting) on air quality for variable meteorological, topological, and other air quality parameters. Air quality modeling is identified as a gap where improved Navy capability will be essential to the future identification and quantification of Navy/Marine Corps range air pollution problems before, during, and after range-related air pollution events may occur.

3.6 Noise Pollution

3.6.1 Noise Regulatory Policy. The Noise Control Act of 1972 (42 USC 4901 et seq.) seeks to protect Americans from noise that jeopardizes their health or welfare. This act directs federal agencies to further this policy within their programs and to develop measures to control the harmful effects of noise on people. Navy and Marine Corps range operations have the potential to cause adverse noise impacts on surrounding communities. State, local and tribal government agencies may also prescribe maximum noise levels to control these impacts. The Noise Control Act does not prescribe retrofit modifications for existing noise sources, however, E.O. 12088 directs federal facilities to comply with all requirements applicable to environmental noise management. Federal facilities must also comply with boundary noise limits established by state and local laws subject to specific exemption.

The Noise Control Act provides only for the prescription and amendment of standards for nonmilitary aircraft noise and sonic boom. Military aircraft, combat equipment, and weapon systems are exempt from new product design standards. However, the DoD initiated the AICUZ program to protect the public's health, safety, and welfare, and to prevent encroachment from degrading the operational capability of military installations in meeting national security. On 19 December 2002, the DON updated the policies, procedures and guidelines for the AICUZ program (OPNAVINST 11010.36B). This program is designed to provide land use recommendations consistent with military objectives and to develop a cooperative approach with the local communities in controlling land uses around military installations. The AICUZ identifies and addresses incompatible development in areas that are adjacent to or in the vicinity of an air installation and subject to rated levels of aircraft noise and/or accident potential.

The Range Air Installations Compatible Use Zones (RAICUZ) program (OPNAVINST 3550.1) is similar to the AICUZ program. The RAICUZ program includes range safety and noise analyses, and provides land use recommendations which will be compatible with range safety zones and noise levels near the range that are associated with the military air-to-ground training and operations. The program's success is dependent upon the local command's success in working with the nearby communities, as well as other federal, state and local agencies, to prevent incompatible development of land adjacent to military ranges (i.e., low level over-flight, drop hazards, and high noise levels). Objectives include protecting Navy and Marine Corps investment by safeguarding the operational range capabilities, precluding public exposure to hazards associated with air-to-ground weapons delivery, and informing the public about the RAICUZ program.

If the RAICUZ study reveals that the type and/or tempo of current range operations is either causing or is likely to cause degradation of the surrounding environment, the National Environmental Policy Act of 1969 (42 USC 4321 et seq.) requires documentation of this in accordance with 32 CFR 775. DON Procedures for Implementing the NEPA requirements are cited in OPNAVINST 5090.1B and MCO P5090.2A standards and procedures.

In addition to the impacts addressed in the RAICUZ study, environmental effects that should be considered include the impacts to endangered species, migratory birds, cultural resources, sensitive habitat such as wetlands and desert areas, marine mammals, and structures. For example, range operations have the potential to adversely impact cultural resources such as historic structures, archaeological sites, Native American rock art, traditional cultural properties, and Native American sacred sites located within the RAICUZ zones. Such impacts trigger Section 106 of the National Historic Preservation Act of 1966 (16 USC 470 et seq.), as well as other historic preservation legislation.

3.6.2 What Is Noise? Noise is defined as an unwanted sound that interferes with normal activities or otherwise diminishes the quality of the environment. Sound perception by the individual, community or species is intangible and subjective. Noise may be intermittent or continuous, steady or impulsive, stationary or transient. Stationary sources are normally related to specific land uses, such as housing tracts or industrial plants. Transient noise sources move through the environment, either along established paths (i.e., highways and railroads), or randomly (i.e., heavy equipment preparing a construction site). There is wide diversity in responses to noise that not only vary according to the type of noise and the characteristics of the sound source, but also according to the sensitivity and expectations of the receptor, the time of day, and the distance between the noise source (i.e., a bulldozer) and the receptor (i.e., a person or animal).

The physical characteristics of noise include its intensity (magnitude), its acoustic frequency spectrum, and its duration. It is a form of energy (acoustic) that is manifested as pressure waves traveling through a medium, such as air or water, at a velocity characteristic of the medium (about 1,100 ft/sec in air at standard conditions for low-pressure amplitudes, i.e., subsonic conditions), and is sensed by the eardrum. As the acoustic energy increases (i.e., the amplitude of the pressure waves increases), at some point the pressure wave will transition into a shock wave where the velocity of transmission now exceeds the speed of sound (i.e., speeds in excess of Mach = 1.0, supersonic velocities). Sound intensity varies widely, from a soft whisper to a jackhammer, and is measured on a logarithmic scale to accommodate this wide range.

3.6.3 Characterization of Noise. The acoustic frequency of sound is measured in cycles per second, or hertz (Hz). This measurement reflects the number of times per second the air vibrates from the acoustic energy. Low frequency sounds are heard as rumbles or roars, and high frequency sounds are heard as screeches. Sound measurement is further refined through the use of "A-weighting." The normal human ear can detect sounds that range in frequency from about 20 Hz to 15,000 Hz. However, all sounds throughout this range are not heard equally well. Therefore, through internal electronic circuitry, some sound meters are calibrated to emphasize frequencies in the 1,000 to 4,000 Hz range, corresponding to the range of greatest sensitivity for the human ear. Sounds measured with these instruments are termed "A-weighted," and are shown in terms of A-weighted decibels (dBA). The duration of a noise event, and the number of times noise events occur are also important considerations in assessing noise impacts. The word "metric" is used to describe a standard of measurement. As used in environmental noise analysis, there are many different types of noise metrics. Each metric has a different physical meaning or interpretation and was developed by researchers attempting to represent the effects of environmental noise.

For comparison sake, the equivalent sound level, L_{eq}, for normal conversation within 5 ft is 60 dBA; a typical vacuum cleaner within 3 ft is 70 dBA, and a typical automobile traveling at 65 mph within 25 ft of the individual is 75 dBA. For the typical listener, a 3-dB change is barely perceptible, while a 5-dB change is quite noticeable. A 10-dB change is twice or half as loud and is quite dramatic to the listener. Scientific studies and social surveys have found that average sound-level metrics are the best measure to assess levels of community annoyance associated with all types of environmental noise.

Airborne noise associated with an action is described in terms of both a single event and time-averaged metrics. The highest sound level measured during a single noise event is the instantaneous maximum sound level (L_{max}). This is the sound level actually sensed by the ear

and is measured with a sound meter set to "slow" response and "A-weighting." A maximum sound level is important in judging how significantly a noise event interferes with conversation, sleep, or other common activities. However, L_{max} alone may not represent how intrusive a noise event is because it does not consider the length of time that the noise persists. Noise from ordnance delivery (blast noise) is impulsive in nature and of short duration. Blast noise is often a source of discomfort for persons, and vibration of buildings and structures induced by blast noise may result in increased annoyance and possible structural damage to NHPA-protected sites. The sound exposure level (SEL) metric combines both the intensity and duration of a noise event into a single measure. SEL does not directly represent the sound level heard at any given time. However, it does provide a measure of the total exposure of the entire event. Its value represents all of the acoustic energy associated with the event, as though it was present for one second. Therefore, for sound events that last longer than one second, the SEL value will be higher than the L_{max} value.

The number of times that noise events occur during given periods is also an important consideration in assessing noise impacts (i.e., Time-Averaged Cumulative Noise Metrics). "Cumulative" noise metrics support the analysis of multiple, time-varying noise events. The most common are the equivalent sound level (L_{eq}), the day-night average sound level (DNL) and the Community Noise Equivalent Level (CNEL) (California only). The L_{eq} metric reflects average continuous sound. It considers variations in sound magnitude over a certain period of time, and reflects, in a single value, the acoustic energy present during the total time period. Common time periods for averaging are 1-, 8- and 24-hour periods. The CNEL metric logarithmically sums all individual noise events and averages the resulting level over a specified length of time. Normally, this is a 24-hour period. Thus, like L_{eq}, it is a composite metric representing the energy average noise level, the duration of the events, and the number of events that occur. However, this metric also considers the time of day during which the noise occurs. This metric adds 5 dB to those events that occur during the evening hours (between 7:00 P.M. and 10:00 P.M.) and 10 dB to those events that occur at night (between 10:00 P.M. and 7:00 A.M.). At 2200 (10:00 P.M.), nighttime officially starts for military flight operations. These "penalties" account for the increased intrusiveness of noise events that occur at during hours when ambient noise levels are normally lower. Noise analyses do include the startle effect due to low-level, high-speed aircraft operations, speech interference, and sleep disturbance if nighttime operations occur. It should be noted that if no noise events occur between 7:00 P.M. and 7:00 A.M., the value calculated for CNEL would be identical to that calculated for a 24-hour equivalent noise level [$L_{eq(24)}$]. This cumulative metric does not represent the variations in the sound level heard. Nevertheless, it does provide an excellent measure for comparing environmental noise exposures when there are multiple noise events to be considered. Typically, sound levels associated with proposed activities are shown as 1-, 8- and/or 24-hour equivalent sound levels [$L_{eq(1)}$, $L_{eq(8)}$ and $L_{eq(24)}$], DNL, or CNEL as applicable. Average Sound Level metrics are the preferred noise metrics of the Department of Housing and Urban Development, the Department of Transportation, the FAA, the EPA, and the Veteran's Administration.

3.6.4 Aircraft-Related Noise Issues. DON policy is predicated on promoting compatibility between air-to-ground range installations, neighboring communities, other federal agencies (i.e., Department of the Interior) and Native American tribes responsible for land management in the vicinity of Navy and Marine Corps ranges. Noise is generated from general human activity on military installations as well as from the military activities on the ranges involving the use of

aircraft, land and marine vehicles (if the range is situated near the water). The majority of marine vessels operating in sea-based ranges are Naval amphibious and support craft. However, recreational vessels, such as powerboats and sailboats that use small auxiliary engines, may also operate in the vicinity of sea ranges, and these internal combustion engines are further transitory sources of noise (both airborne and underwater) when these vessels operate near the range. Ground vehicular operations can be significant sources of noise, but the effects from them are more localized and are more easily managed and reduced to acceptable levels. The noise generated by rotary wing aircraft can be extremely disruptive, but management of helicopter operational areas and the installation of passive noise control measures often reduces this noise to acceptable levels near human activities. There is room for concern, however, on the potential effect of low-flying helicopter operations on wildlife (see below).

Noise generated by the military's aircraft gas turbine (jet) engines in the atmosphere and by sonar operations in the ocean presents the Navy with two of its most pressing environmental problems. In particular that noise that is generated by the new, more powerful, F414 and still newer high-thrust engines that will follow it. Steps in reducing noise levels from these engines, in flight, are being explored by the engine manufacturers and others. Drastic steps are required to achieve noise reductions of only a few decibels, and such steps as carrying water aboard aircraft for spraying into the exhaust plume for noise attenuation are being explored. Reducing the noise from the increasingly powerful Navy jet engines is pushing the limits of what can be achieved, technologically.

There is no approved current plan for acceptably basing and operating the new aircraft that will be coming to the fleet within the next decade. Rather, several of the approaches being considered are: (a) incorporating new engine features on board the aircraft that would lessen the noise produced during flight, (b) measuring the magnitude and directivity of in-flight noise to assist in providing improved noise contours for proposed and operating air fields, (c) developing improved noise abatement devices for stationary testing of engines, and (d) development of noise generation and acoustical propagation models. Work is on-going in these areas, but all problems remain unresolved and technology gaps exist.

Other than reducing the noise levels produced, it is equally important to better characterize both the intensity and the directivity of the noise produced. It is especially important to have the latter type data for in-flight aircraft, and the DoD is in the process of designing and constructing an aircraft "noise test range" where aircraft with new and other engines will be able to fly through a marked course at low altitude (1000 ft) for characterization of the in-flight noise. These improved characterizations of engine produced noise will be used in developing the improved noise contours required as part of the AICUZ and RAICUZ programs.

In addition to noise generated by high-thrust jet aircraft engines in flight, the noise generated by these same engines during stationary run-up while in or out of aircraft can create issues at home bases. When jet engine test cells or hush-houses are available for run-up, noise is not normally an issue in either case. Although work is on-going in this area and should be continued, noise produced during stationary testing is not normally a range issue.

For air-to-ground ranges where noise-sensitive land uses exist or the potential for development is present, detailed noise impact analyses are warranted. Such noise analyses should address aircraft noise, ordnance (blast noise), and supersonic operations, if applicable. Noise contours provide the best method of quantifying and depicting noise impacts. Noise contours should be developed for existing and proposed operational alternatives to evaluate the potential change in noise exposure on and off the range. Each installation is responsible for maintaining

operational data required to develop noise exposure contours. The noise impact depicted by aircraft noise exposure contours are described by the DNL (or Ldn) or Community Noise Equivalent Level (CNEL) in the State of California. Both of these metrics are single number descriptors representing a 24-hour time weighted logarithmic average with specific penalty adjustments during nighttime hours (10 P.M. – 7 A.M.) for the DNL metric and during evening hours (7 P.M. – 10 P.M.) and nighttime hours for the CNEL metric.

For land use planning purposes, the noise exposure from aircraft is divided into three noise zones: Noise Zone 1 (DNL or CNEL < 65) is an area of minimal impact where Naval interests are not required to attenuate sound; Noise Zone 2 (DNL or CNEL between 65 and 75) is considered to be an area of moderate impact where some land use controls are needed; and Noise Zone 3 (DNL or CNEL 75 and above) is the most severely impacted area and requires the greatest degree of compatible land use controls.

Other than determination of noise levels created by aircraft, the effect of aircraft and noise from other military operations on ranges (e.g., explosives and vehicular operations) on range wildlife remains under investigation.

3.6.5 Noise Models. A number of projects have been undertaken by SERDP and the Army to analytically model the atmospheric transmission noise, blast effects, and effects on structures. They include (see Section 4.2.4.8 for further details): "Training and Testing Range Noise Control (Army)," expected to be completed in FY06; "Advanced Acoustic Models for Military Aircraft Noise Propagation and Impact Assessment (SERDP CP-1304)," project began in FY02; "Controlling, Assessing, Managing, and Monitoring the Noise Impacts from Weapons, Helicopters, and Aircraft on Training Readiness (SERDP CP-523)," project was completed in FY97; "Airborne Weapons Noise Prediction (SERDP CP-1397)," project is ongoing and anticipated to be complete in FY07; "Prediction Model for Impulsive Noise Impacts on Structures (SERDP CP-1398)," project is ongoing and anticipated to be complete in FY07; "Assessing and Controlling Blast Noise Emission (ESTCP CP-0006)," project demonstrated two new blast noise models: BNOISE2 for artillery and explosive operations and Small Arms Range Noise Assessment Model (SARNAM) for small arms ranges (SARs). Completed FY02.

Most of these projects are still underway with ambitious goals. It is not yet clear what further modeling will be required, although it is equally clear that some will be required.

3.6.6 Effect of Noise on Endangered Species. Data on the effect of noise from Navy/Marine Corps training activities on specific species are difficult to come by. However, some Navy data are available and significant data from the USFWS from their field installations nationwide also is available (see Table 3-3). The USFWS data allow one to conclude that, for a variety of species occurring at locations near military bases, noise effects have occurred and could occur under Naval training operations. For example, the USFWS survey provides useful data on the possible effects of the military low-altitude aircraft noise on fish and wildlife (Gladwin et al., 1987), and found that various types of military, commercial, and private aircraft have been responsible for disturbing wildlife on and near military installations. The reported impacts on wildlife range from minor behavioral responses to severe changes in the use of an area. Information on the relationship of the observed reactions to physiologic, population, and reproductive effects for most species and situations were unknown to the survey, but the following are some important survey results.

Table 3-3. Survey Records of USFWS Field Offices on Effects of Noise and Sonic Booms on Fish and Wildlife

Item	State	Year	Aircraft	Animal	Issue
1	CA	1987	Military/private/ Small propeller/small jet/helicopter	Birds/ waterfowl	Frequent overflights are causing serious disturbances to Refuge waterfowl, especially geese. Helicopters are more disruptive than wing aircraft. Aircraft-induced stress is believed to be making waterfowl more susceptible to disease.
2	HI	1987	Military/small jet/helicopter	Birds/waterfowl/ raptors/passerines/ mammals/bats	The Area Office initiated a formal Section 7 consultation for a proposed U.S. Air Force low-altitude route in Hawaii. It is believed that the route could have an adverse effect on endangered species including the Hawaiian hawk, Hawaiian goose and Hawaiian hoary bat as well as several species of passerine forest birds.
3	NV	1987	Military/small jet/large jet/helicopter	Birds/colonial nesting	Infrequent low-altitude aircraft operations are flushing pelicans.
4	NV	1987	Military/small jet/large jet/helicopter	Mammals/ ungulates	A possible impact to desert bighorn sheep is suspected due to a declining population and extensive and intensive aircraft operations.
5	NV	1987	Military/small jet/large jet/helicopter	Birds/waterfowl/ shorebirds/other	Frequent low-altitude aircraft operations are constantly disturbing (flushing) waterfowl, shorebirds, and other Refuge birds.
6	NV	1987	Military/small propeller	Fish	An experiment done in cooperation with the USAF showed that a mild sonic boom had no effect on fish eggs.
7	OR	1987	Military/small jet/helicopter	Mammals/ ungulates	Antelope are exhibiting panic running behavior as the result of low-altitude jet fighter aircraft.
8	WA	1987	Military/ helicopter	Birds	Virtually all Refuge ducks, geese, and swans will take flight at the sound of approaching helicopters and remain airborne until the helicopters can no longer be heard. A formal written complaint has been made to the military.
9	WA	1987	Military/private/ small propeller/ small jet/ helicopter	Birds/waterfowl	Frequent overflights, even as high as 3,000-4,000 ft above ground level cause brant to panic flush and leave the area for hours, sometimes missing the next low-tide feeding opportunity.
10	AZ	1987	Military/small jet	Mammals/ ungulates/birds/ upland game	Reactions to intense sonic booms vary from alert and startle in bighorn sheep, jumping and running in Sonoran pronghorn and frequent flushing by birds. Most wildlife of the wildlife refuge appear to have habituated to the repetitive sights and sounds of low-altitude aircraft flights that have taken place in the area over the past 40 years. The refuge is concerned about the intense aircraft operations over the lambing grounds of the Sonoran pronghorn.
11	AZ	1987	Military/ commercial/ private/small propeller/small jet/helicopter	Mammals/ ungulates/fish	Aircraft noise and sonic booms are having no effect on fish at the hatchery. It is suspected that aircraft are having an adverse effect on desert bighorn sheep, especially at calving time.

Table 3-3. Survey Records of USFWS Field Offices on Effects of Noise and Sonic Booms on Fish and Wildlife (cont'd)

Item	State	Year	Aircraft	Animal	Issue
12	OK	1987	Military/ private/small propeller/small jet/helicopter	Birds/waterfowl	Waterfowl will flush and remain airborne for varying lengths of time when low-altitude aircraft are over the Refuge.
13	OK	1987	Military/ private/small propeller/small jet/helicopter	Mammals/ ungulates/birds/ waterfowl	Refuge animals are being startled by aircraft and are exhibiting alert behavior. Waterfowl will flush and remain airborne for varying lengths of time when low-altitude aircraft are in the vicinity. Buffalo, longhorn cattle, deer, and elk have apparently habituated to the aircraft.
14	TX	1987	Military/ commercial/ private/small propeller/small jet/helicopter	Birds/ upland game	A study on the effects of low-altitude aircraft on Attwater's prairie chickens showed no adverse impact.
15	TX		Military/ private/small propeller/small jet/helicopter	Birds/colonial nesting	Low-altitude overflights flush breeding birds, particularly brown pelicans, and can cause panic reactions that result in lost eggs and young. Repeated flushing can cause abandonment of the rookery.
16	TX	1987	Military/ commercial/ private/small propeller/small jet/helicopter	Birds/waterfowls/ seabirds	A Corps of Engineers permit to construct an airstrip on St. Matthew Island was denied because of aircraft noise impact to adjacent seabird nesting cliffs. USAF flight training near Lake Louise was objected to because of impact to calving caribou. Seabirds nesting 50 miles east of Nome had habituated to the frequent low overflights of commuter aircraft.
17	CA	1987	Military/ commercial/ private/small propeller/small jet/large jet/helicopter	Birds/raptors	It is believed that aircraft noise and sonic booms to some degree helped lead to the demise of the California Condor.
18	HI	1987	Military/ small jet/ large jet	Birds/other	Low-altitude military overflights are believed to be causing the endangered palila bird to underutilize a sizable portion of its critical habitat. A research study has been initiated.

- Helicopters appear to cause a greater flight/fright response in wildlife than fixed-wing aircraft.
- Waterfowl were by far the most frequently reported animal group disturbed by aircraft.
- Some species of waterfowl are completely driven off regular refuges by frequent aircraft activity.

- Low-altitude aircraft have caused ungulates to stampede, e.g., desert bighorn sheep and pronghorn.

- There were concerns for potential adverse effects of low-altitude aircraft over fawning/calving grounds (e.g., endangered Sonoran pronghorn antlope).

Some Navy data on the effect of noise from Navy and Marine Corps training operations on wildlife and endangered species is also available. Noise sources considered are jet aircraft, helicopters, ships, and explosions. Five of six military installations contacted reported either no endangerment of species or no known problems and data on this issue. The sixth military installation reported that noise disturbances to endangered species result mainly from target drone launches, aircraft over-flights, and airshows. Observed effects included:

1. Birds are displaced from active nests exposing eggs or young to predation and environmental stress (heat and cold).
2. Excessively loud noise may cause permanent hearing damage, thus causing an individual's ability to function.
3. The stress of a noisy environment may lead to physiological changes that lower reproductive success and eliminate otherwise suitable habitat as a nesting area.

Measures taken to mitigate these disturbances and their potential effects included: (a) limit rate of explosive ordinance disposal to less than 2 lb of C-4 per detonation, keeping decibels to below 98 dB; (b) coordinate plans for airshows to minimize their effect on listed species; (c) keep aircraft flying at or above 500 ft over listed species habitat areas, with exception to landings, take-offs, and airshows.

An incident in which animal environmental advocates have objected to Navy training operations and exercise due to impacts of aircraft or ship noise to endangered species is described in Table 3-4.

Table 3-4. Incident of Public Resistance Due to Effect of Noise on Endangered Species

Issue	Potential Noise Effects
Navy's proposed construction of an Outlying Landing Field in Washington County, North Carolina, September 2003.	Noise from constant aircraft landings and take-offs and low altitude flights will disturb resting and feeding waterfowl. Frequent disturbance can lead to abandonment of areas and impacts to the overall fitness of the affected waterfowl.

3.6.7 Underwater Noise. Sound propagation characteristics are different in water than in air. Sound levels for both mediums are calculated as a ratio of the measured acoustic energy to a reference value. The reference level for airborne sound is 20 micropascal (µPa), consistent with the minimum level detectable by humans. However, a reference level of 1 µPa is used for underwater sound because a reference based on the threshold of human hearing in air is not appropriate. Also, the source levels of airborne noise are conveniently measured at 1,000 ft (305 m). For underwater sound sources, the standard reference range is 3.3 ft (1 m) to permit use with transmission loss measurements referenced to 3.3 ft (1 m). As a result, waterborne sounds can only be meaningfully compared to airborne sounds if a 26-dB correction factor is added to airborne

sound levels. Two common unweighted metrics used to measure underwater sound are the peak sound pressure level (Peak) and the root mean square (RMS) sound pressure level (SPL). The former is based on the instantaneous maximum positive or negative pressure observed during the impulse; the latter represents the mean square pressure level of the pulse and is the metric used by the NMFS as a criterion for judging noise impacts to marine mammals. Airborne sound can be transmitted into the water. However, the amount of acoustic energy directly transmitted from a source is limited due to refraction and reflection. Sound transmission in shallow water is also influenced by reflection losses from the bottom and the surface, refraction from sound speed gradients, reflection and refraction from shallow bottom layers, and scattering from rough surfaces.

The underwater effects of noise are being investigated by NAVSEA and is not considered further here.

3.7 Range Management

Range management is a broad category and covers a wide range of topics, including:

- Range Residue
- Risk Assessment
- Geographical Information System (GIS)
- Undersea Cables
- Cultural Resources, Urban Encroachment issues, Invasive Species.

3.7.1 Range Residue. The Navy and Marine Corps annually expend approximately 25,000 tons of munitions on their operational ranges (Naval Strike and Air Warfare Center, 2001). Significant additional quantities remain at closed, transferred, and transferring ranges. Operational ranges are used intensively for the testing and training of weapons systems to maintain our warfighting capability. This section discusses the impacts of wastes generated from use of operational terrestrial ranges.

Military training and testing requires the firing and bombing of practice and live munitions upon operational ranges. Use of these ranges leaves expended MEC, fragments of expended munitions (i.e., fins from practice bombs), remains from target objects, degrading MEC, other constituents, and scrap metal and debris (Figure 3-1). These munitions-related wastes are collectively termed range residue.

MEC can be munitions that are unexploded, abandoned, discarded; soil with an explosives concentration high enough to present an explosive hazard; and facilities, equipment, or other materials contaminated with a high enough concentration of explosives to present an explosive hazard. MEC was formerly known as ammunition, explosives, and other dangerous articles (AEDA).

Because of safety concerns, the Navy and DoD have expressed a heightened interest in the management and disposal of range residue. The management of range residue consists of periodically clearing designated range areas, collecting the residue, and moving it to another location. At this point range residue is considered material potentially posing an explosive hazard (MPPEH).

Figure 3-1. Expended Munitions Remain on Range

For disposal, MPPEH is demilitarized on site or moved to a central location for demilitarization. Demilitarization is meant to prevent further use of munitions for their originally intended purpose. The demilitarization process crushes, deforms, or mutilates each type of munition until it no longer resembles a munition. After demilitarization the residue is still considered MPPEH and must be certified before disposal at Defense Reutilization and Marketing Office (DRMO) or sent to recycling at a qualified recycling program (QRP).

Processing range residue can be problematic and difficult. Processing options consist of disposal, recycling, and open burning or open detonation. For disposal to DRMO or to a scrap yard or waste facility, qualified personnel again must certify the quantity being disposed does not present an explosive hazard. Certification also is required for recycled metals before they can be sold on the market. Prior to certification the material is still considered MPPEH. Scrap metal is more difficult because additional certification (sometimes twice) is required before material is transferred to DRMO, a scrap yard, recycled, or is sold to the public directly. The concern is that the processed material may still contain explosives, energetic, or other dangerous items.

3.7.1.1 Range Clearance. Range clearance of expended munitions is required to keep operational ranges safe and usable. Range areas where MEC could reside are cleared including the impact or target area, downrange areas, firing positions, and adjacent lands (Figure 3-2). Ranges are first certified to be clear of UXO, and any UXO found is removed or detonated in place. The

Figure 3-2. Typical Munitions and Explosives of Concern Requiring Removal

specific clearance operations are generally determined by the installation. Some ranges are swept as often as every week because of heavy use. Other ranges are cleared annually or less frequently. Clearances may be visual or swept with a detector down to about 2 ft.

During a review of eight military facilities with operational ranges, the DoD Inspector General determined each base had range clearance and disposal programs sufficient to protect the public health. However, six of the eight facilities cleared debris and residue around target areas only and did not dispose of the waste. At two of the facilities only target areas were cleared to ensure range usability. Funding constraints and the necessity to maintain targets were cited as reasons (DoD, 2000). Therefore, there is likely a considerable quantity of range residue outside the target area that remains to be cleared from Navy ranges. For example, at China Lake Naval Air Warfare Center Weapons Division (NAWCWPNS), the costs for clearing MPPEH from ranges is around $600 per ton. The range team is currently removing 300 to 400 tons per year from 2,000 tons of residue stockpiled all the range holding areas (RHAs).

3.7.1.2 Collection. After range clearance, range personnel or contractors collect the MEC and other materials such as target debris, scrap metal and any other wastes. This range residue is then segregated and stockpiled. Each collected munition is segregated and sometimes inspected for explosive material.

Collection and separation can be tedious because of the many different types and sizes of munitions used by the Navy and Marine Corps. Some of the munitions used on terrestrial ranges include rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, land mines, propellants, explosives, pyrotechnics and chemical warfare agents (Figure 3-3).

Figure 3-3. Many Types of Munitions Used Makes Collection Challenging

3.7.1.3 Storage and Stockpiles. Cleared and collected range residue is stockpiled and classified as MPPEH (Figure 3-4). Some ranges store collected range residue in stockpiles called RHAs. Other ranges can only afford to keep the target areas free from residue. Range residue can be segregated and directly processed at the RHA or it may arrive at the holding area already segregated (Figure 3-5).

Figure 3-4. Segregated and Mixed Stockpiles of MPPEH

Figure 3-5. Segregated and Demilitarized Stockpile of MPPEH

DoD has safety deficiencies in the handling of stockpiled range residue. MPPEH range residue and other waste and scrap items have been found commingled (DoD Inspector General, 2000). The DoD manual requires MPPEH to be segregated from other types of scrap material. Also, increased safety concerns from MPPEH has slowed or stopped the processing of range residue in stockpiles at some facilities (Naval Strike and Air Warfare Center, 2001).

There are environmental concerns associated with stockpiled material and RHAs. Stockpiles and RHAs should be covered to prevent stormwater contamination from residual explosive constituents. Installation stormwater pollution prevention plans may require covers and monitoring of stormwater for constituents of concern. Depending on the stockpile size, nature of the residue, and length of time MPPEH remains stockpiled, paved surfaces or pads for storage may be necessary to prevent leaching of contaminants into the soil. And where possible, range residues should be handled in containers (drums, rolloffs) that are covered (lid, tarp) when not in use.

3.7.1.4 Demilitarization. Depending on type of MPPEH collected, demilitarization may be required before the material can be later processed or disposed. Demilitarization is required to remove the military characteristics from used munitions. Methods of demilitarization include resource recovery, recycling, remanufacture, disassembly, reclamation, mutilation, alteration,

destruction, treatment and disposal (e.g., see Figure 3-6). The intent is to prevent the further use of the munitions for its originally intended purpose and to remove the appearance it was once a military munition.

Figure 3-6. Demilitarization by Alteration of Expended Bombs and Armored Target Item

Demilitarization can be performed at the RHA or a centralized processing facility. Demilitarized range residue may or may not be in a form usable and safe for further processing. It may require certification or turnover to DRMO, or direct sale or disposal in the private sector.

3.7.1.5 Processing. Processing of demilitarized MPPEH is the final step in range residue management. In some cases demilitarization is performed before processing. Processing usually consists of either disposal or recycling. Each installation seems to have its preferred processing method. Some have centralized range residue processing on the installation. Other bases process stockpiled range residue somewhere on the installation away from operational ranges. And some installations send their demilitarized, inert range residue off base for processing.

On-Site, Centralized Processing. Centralized or on-site processing is being performed at Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, California. Since 2000, Twentynine Palms has been processing range residue in a single facility called the range residue processing center (RRPC). Residue is considered MPPEH upon entrance to the center and is visually certified by resident, qualified UXO technicians.

The range residue is processed according to the type of spent material. Equipment permanently located at the RRPC includes a deformer, hammermill (Figure 3-7), aluminum melting furnace (Figure 3-8), and a heavy duty shredder. Recovered resources include brass, aluminum, and low-value scrap metal. Low value MPPEH is demilitarized by cutting, shredding, and crushing.

A final certification by RRPC personnel and the purchasing representative is conducted prior to removal. Depending on the final product, processed material is offered to the Defense Reutilization and Marketing Service (DRMS) and the established QRP. Use of the QRP and sale to the public generates funds. These funds could contribute to enhancing range residue management (MCAGCC, 2002).

Figure 3-7. (From left to right) Deformer, 20-mm Cartridges, Hammermill, and Small Arms

Figure 3-8. (from left to right) Aluminum Melting Furnace; Processed Aluminum

On-Site, Decentralized Processing. Marine Corps Air Station (MCAS) Yuma operated a decentralized range residue processing system. Five RHAs are used to stockpile range residue from two range complexes. Because the stockpiles are considered MPPEH, systematic inspections for energetics were conducted first.

Unlike Twentynine Palms, the Yuma range residue removal effort was primarily contractor-operated. However, the processing steps were similar. Initial inspection was performed by a team for hazardous wastes, low-level radioactive waste, and MPPEH.

Once materials were identified, the contractor segregated and containerized residue items according to their nature. Hazardous and low-level radioactive waste were placed in a secure area and disposed of by MCAS Yuma personnel. UXO and energetic items were set aside for disposal by MCAS Explosive Ordnance Disposal (EOD) team. Inert range residue was demilitarized and partially processed to permit direct acceptance by authorized recycling mills or disposal (Figure 3-9). Before shipment the containerized range residue was certified inert (MCAS, 2000).

Off-Site Processing. Another possibility for demilitarization and processing of range residue is to transport MPPEH to an off-site facility. The facility would be designed to demilitarize/process the large quantities and many varieties of range residue. A survey was prepared to explore the off-site concept (Naval Strike and Air Warfare Center, 2001). The facility studied is the Army demilitarization and depot facility at remote Hawthorne, Nevada, known as the Hawthorne Army Depot.

Figure 3-9. Decentralized Processing of MPPEH Using Transportable Equipment

Off-site processing could be advantageous to some installations. Range operators could schedule collections as needed, would not require extensive RHAs, and would not have the burden of demilitarization and processing.

There are some disadvantages to off-site disposal. The burden of safety would be on the installation to certify the MPPEH as inert before pickup. Responsibility for safety has become a significant issue regarding range residue. In fact, the inability to render collected residue safe has caused the DRMS to impose a moratorium on the sale of range residue (DOW, 2003a). Similar problems would be expected with an off-site recycling and disposal facility.

Multiple Processing Techniques. Another method for range residue management is to incorporate more than one technique to optimize residue removal and processing for certifying processed MPPEH is inert.

Multiple MMPEH processing is currently being used at China Lake NAWCWPNS. China Lake first ensures range residue stored in RHAs is safe for storage until processing. After removal from RHAs, the range residue is separated by type or remains commingled, certified inert, demilitarized, processed, certified safe, and transferred off base in one of the following methods depending on type of MPPEH:

(1) Inert certification, separation, safety certification, and direct transfer to QRP without further processing;
(2) Shredding, shearing, flashing; safety certified; and then transferred to DRMO;
(3) Off-site processing after inert certification and demilitarization of commingled MPPEH.

In addition to multiple processing methods, NAWCWPNS is developing an instruction to standardize MPPEH management. The instruction will enable the various teams involved in range residue management to be consistent and safe during the process. Entities involved in the process include EOD, civil servants, and contractors. China Lake has a diverse array of MMPEH because in addition to training operations they perform extensive R&D testing of munitions-related products. The diversity of munitions used at NAWCWPNS makes the management of MPPEH especially difficult.

3.7.1.6 Environmental Issues. Another problem with managing range residue are requirements of the Military Munitions Rule (MMR). MMR requirements can activate RCRA requirements, which can render certain types of residue as solid or hazardous waste. According to one study,

> The most favorable position that can be advanced by DoD is that metallic range residues destined for recycling by melting for metals' recovery are excluded from the definition of "solid waste" as "excluded processed scrap metal" [40 CFR 261.4(a)(13)] and, therefore, cannot be hazardous waste subject to Subtitle C controls. Section 3.3.3 describes the five decision factors that led EPA to finalize the exclusion; the most significant of which is that "processing" of the scrap metal occur (U.S. Army Environmental Center [USAEC], 1999).

A multitude of different types of range residue exists and each has its own pathway toward final disposition. DoD 4160.21-M defines the demilitarization, recycling, and disposal of MPPEH. Spent brass from less than 0.50 caliber and metal gleanings in the range residue that have been crushed, shredded, or otherwise destroyed (demilitarized) are eligible for recycling to a QRP (DOW, 2003b).

Some MPPEH is considered hazardous waste and therefore cannot be recycled (e.g., smoke pots) and are subject to the RCRA land disposal restrictions. As a generator, DoD must identify the constituents to the treatment or disposal facility to ensure proper treatment before land disposal or incineration. There also is a requirement to separate and identify collected range residue by installation personnel.

Range residue and scrap also can pose a hazard to the environment. MPPEH can release hazardous constituents at any point during the process. Chemicals from range residue are released to soils, groundwater, and air. Hazardous chemicals may affect humans and ecological receptors through a wide variety of pathways including, but not limited to, ingestion of groundwater, dermal exposure to soil, and various surface water pathways.

Insufficient usage data and limited scientific information makes it difficult to determine the environmental impacts of munitions use and range residue on ranges. Environmental concerns over expended munitions and range residue may be impacted by determining the amount, type, and location of munitions fired; characterizing air emissions and releases to the

environment; understanding fate and transport mechanisms of dangerous chemicals; and obtaining chemical toxicological characteristics.

3.7.2 Risk Assessment at Active Ranges. There are no legal drivers requiring the assessment of risk at active ranges. Because the release of munitions on an active range is being done for its intended use, the release is not classified as a hazardous waste (HW) release and is therefore not regulated. However, munitions constituent migration off an active range does constitute an HW release and is regulated. If it is determined that an off-range release poses an unacceptable risk to human health or the environment, then a CERCLA response may be required to mitigate the risk.

Although not regulatory-driven, the Navy has established a RSEPA Policy Implementation Manual (U.S. Navy, 2003) outlining a process to assess the environmental conditions at all Navy land-based operational ranges (excluding water ranges and SARs). The RSEPA process is loosely based on the CERCLA risk assessment process. Under CERCLA, sites are evaluated for risk to both human health and ecological risk through a tiered approach. First the site is screened against toxicity benchmarks. If concentrations exceed the benchmarks (or there are no benchmarks), then the sites move into a baseline risk assessment. During the baseline, more site-specific benchmarks are used and site-specific toxicity data may be collected to reduce uncertainty and better define risk at the site. RCRA has a similar requirement to assess risk from HW management practices. The RCRA process varies by state but generally follows the process of screening then refining to more site-specific conditions.

The RSEPA Program identifies a detailed approach for determining whether there is an unacceptable human or ecological risk migrating off the range. The process begins with the Range Condition Assessment (RCA). During the RCA, ranges are selected (Phase I), an off-site compliance review is conducted to gather the existing records and other data to help assess the environmental condition of the range (Phase II), and an on-site visit is completed (Phase III) to determine any potential for off-site constituent migration that may be posing risk. During the RCA Phase III site visit, an Operational Range Site Model (ORSM) is developed to identify sources, potential pathways and receptors of concern for the site. This model is analogous to the Conceptual Site Model (CSM) prepared for a Human Health and Ecological Risk Assessment at a CERCLA site. The goal of the RCA is to identify any impacts to the environment from range operations. Decision Point 1 comes at the completion of the RCA Phase III step and is used to determine if mitigation measures are needed, further evaluation is warranted, or no further action is required. Phase IV of the RCA is used to develop, implement and monitor any required mitigation measures at the range.

If further evaluation is warranted, a Comprehensive Range Evaluation (CRE) is initiated to identify and collect the necessary data needed to confirm and analyze the potential risk of any release. During the CRE Phase I – Preliminary Screening, the range will be analyzed for the presence or absence of MCs that have the potential to migrate off-range and pose a risk to human health and the environment. Sampling during this phase is to be identified through the Systematic Planning Process and use of Data Quality Objectives (DQOs) in order to limit it to a single event. Focus is on dynamic work plans and field test methods to verify and refine the pathways identified in the ORSM and identify any necessary interim mitigation efforts. In addition, the CRE Phase I may include modeling studies to fill data gaps. A Range-Specific QAPP, based on the RSEPA Master QAPP, is to be developed for all sampling and data requirements.

Any exceedance of the munitions constituent screening values will require an evaluation for mitigation measures or the need to proceed to Phase II of the CRE. The goal of the CRE

Phase II – Verification Analysis is to verify evidence of off-range releases posing unacceptable risk through the use of more conservative assumptions in a Range-Specific Screening Risk Assessment (RSSRA). During this effort, human health risk will be assessed using chronic exposures based on off-range current and future land use. For the ecological risk component, the exposure scenarios are to focus on site-specific off-range receptors only. However, there may be times when long-term effects to receptors on-range will need to be considered as well. The focus of the ecological risk efforts is on keystone species or regionally significant species. Effects on TES and their habitats are to be assessed through the NEPA process and not the RSEPA process. A finding of unacceptable risk can lead to the need for protective measures, a CERCLA response, or both. The final component of the RSEPA process is Sustainable Range Oversight (SRO). SRO will be a critical component of all CERCLA investigations or responses to ensure that there is no adverse impact to the long-term sustainability of the range operations.

Issues associated with assessing unacceptable risk from migration off active ranges are similar to issues assessing risk at any CERCLA site. Inherent in the risk assessment process is uncertainty and conservatism that can make risk decisions difficult. Uncertainty is introduced into the process whenever there is insufficient site-specific data to fully assess a receptor or pathway. To compensate for the inherent uncertainty, a higher degree of conservatism is built into the risk process to ensure that unacceptable risk is not missed. In addition to land based ranges, the Navy has a significant number of active ranges involving wetlands, nearshore and offshore environments. Methodologies to assess risk to these environments are problematic and not well defined or agreed upon by the regulatory and scientific community. The CERCLA risk assessment process can be utilized for these environments. However, there are a number of issues associated with MC degradation rates, mobility, corrosion rates, fate and transport, and toxicity in the marine environment that introduce significant uncertainty in the evaluation of risk. These will be discussed in Chapter 5.

3.7.3 GIS Technology and Navy Ranges. This section provides an overview of the current and planned efforts of using GIS to provide various levels of responsibility for the information necessary to manage and sustain ranges for military readiness.

A GIS is a convenient and flexible tool for viewing different levels of information with reference to a location on the earth. The basic map can have added layers, such as:

- Facilities
- Utilities
- Roads
- Vegetation
- Land Use
- Communications
- Hydrography
- Bathymetry
- Geology
- Weather Patterns
- Explosives Safety Quantity Distance (ESQD) Arcs
- Natural Resources
- Environmental Hazards
- Protected and Endangered Species Areas

- Range Target Data
- Weather
- Noise Contours
- Urban Areas.

The Navy currently is attempting to consolidate and coordinate all the efforts being pursued at each military base. According to a recent data call by NAVFAC in preparation for the upcoming Base Realignment and Closure (BRAC) efforts, a number of bases are highly advanced in their GIS skills and data, while others have little access to GIS. Of the multitude of information and committees focusing on GIS, one of them is NAVFAC's GeoReadiness effort that is very similar to the Air Force's GeoBase concept. Similarly, the Army is creating a "Geospatial Information System Repository" (GIS-R).

Within the Navy sphere of influence, the main GIS efforts are based on the Regional Shore Installation Management System (RSIMS), Integrated Installation Management (I2M), Regional Shore Infrastructure Planning (RSIP)-Link, Navy and Marine Corps Range Information System (NMRIS), and Internet Navy Facilities Assets Data Store (iNFADS), with the overall architecture being GeoReadiness which accesses the base data up to the executive level (see Figure 3-10). In addition, Explosives Safety Siting (ESS) is being developed at a DoD level to use the Internet Navy Facilities Assets Data Base (iNFADB) and site GIS features and coordinate with the GeoReadiness Repository.

RSIMS includes the Pacific Rim areas. Once access is granted through a user I.D. and password, the user can access various environmental layers, range management issues, facility

Figure 3-10. Regional Shore Installation Management System

layers, and others as set up by the site. The Web site is an ArcIMS application and is maintained at NAVFAC Information Technology Center (NITC).

I2M is promoted by the Combat Logistics Force (CLF). I2Mp uses "the latest technology to integrate 14 vital business processes and align them with a common data set across the entire fleet."

I2M includes the following options:

1) Update Property Records
2) Manage Inspection Program
3) Conduct Inspections
4) Receive Work Requests
5) Prepare Automated Information System (AIS)
6) Prepare Installation Readiness Reporting System (IRRS)
7) Package Deficiencies
8) Create Integrated Priority Lists (IPLs) and Maps
9) Prepare Budget Exhibits
10) Prepare 1391s
11) Allocate Facilities Sustainment, Restoration and Modernization (SRM) Dollars
12) Authorize and Fund Work
13) Track Authorized Work
14) Evaluate Execution.

Naval Air Systems Command (NAVAIR) at Patuxent (Pax) River has developed an Integrated Range/Installation GIS framework. Figure 3-11 describes Pax River successes.

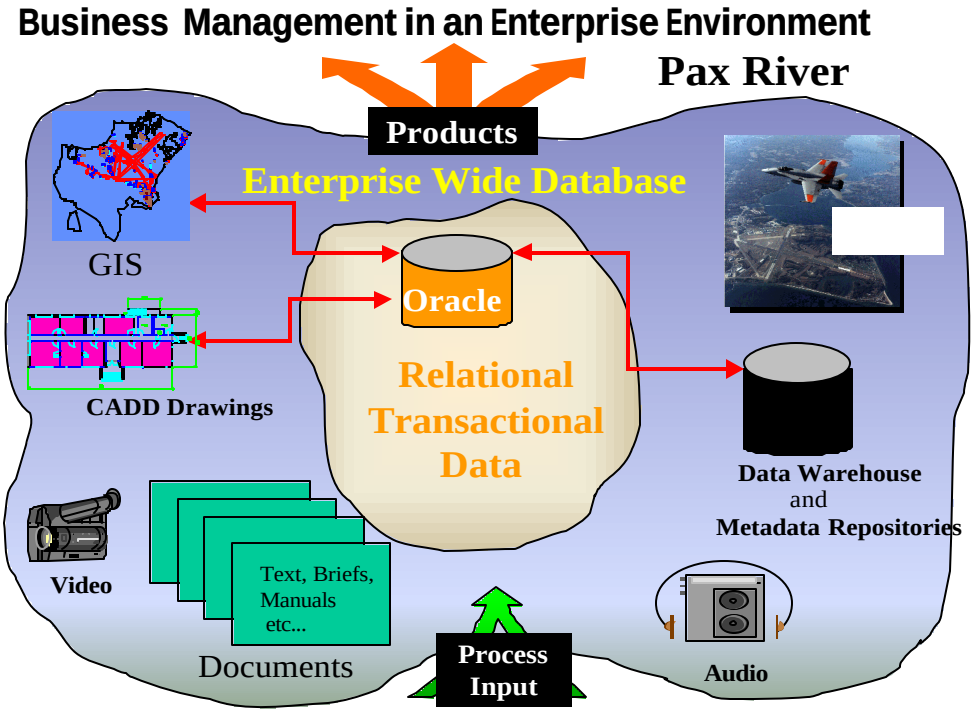

Figure 3-11. NAS Patuxent River, "Islands of Success" –I2M Applications

NITC maintains the NMRIS, a Web-enabled database developed to house text and map/geographical data pertinent to Navy/Marine Corps air-to-ground ranges in one place. The database was developed by TAMS Consultants, Inc. (a subsidiary of EarthTech) and was migrated to NITC Port Hueneme, the Webmaster. It is a secure, user name/password-protected site. NAVFAC developed the database as part of its responsibilities for range planning and RAICUZ in coordination with N44's Air-To-Ground Range Needs Assessment in September 2000. This Needs Assessment became the template for the follow-on Ranges-to-Readiness (R2R) efforts of CLF and Commander, U.S. Pacific Fleet (CPF). RAICUZs will become part of the Theater Assessment Plan. The site is designed to inform range users and range managers of the various range capabilities of the Navy and Marine Corps. Currently the data is for air to ground activities, but there are plans for developing this ArcIMS application further and expanding the data to water.

Figure 3-12 identifies the range complexes involved in NMRIS. Two individual range sites are shown: Camp Lejeune with imagery (Figure 3-13), and Camp Boardman without imagery (Figure 3-14).

Range managers are responsible for keeping the information current for their range. Range managers will have the capability to edit the text data for their range only. Mapping data will have to be sent to NITC for changes. NITC will have 24/7 service and GIS support. All other users will have read-only capability. Efforts are coordinated with N43 and will be integrated into the future Navy Range Management System.

There is no information on where the NMRIS database is obtained or if the database is related to the Navy Range Database. The Navy Range Database is explained elsewhere.

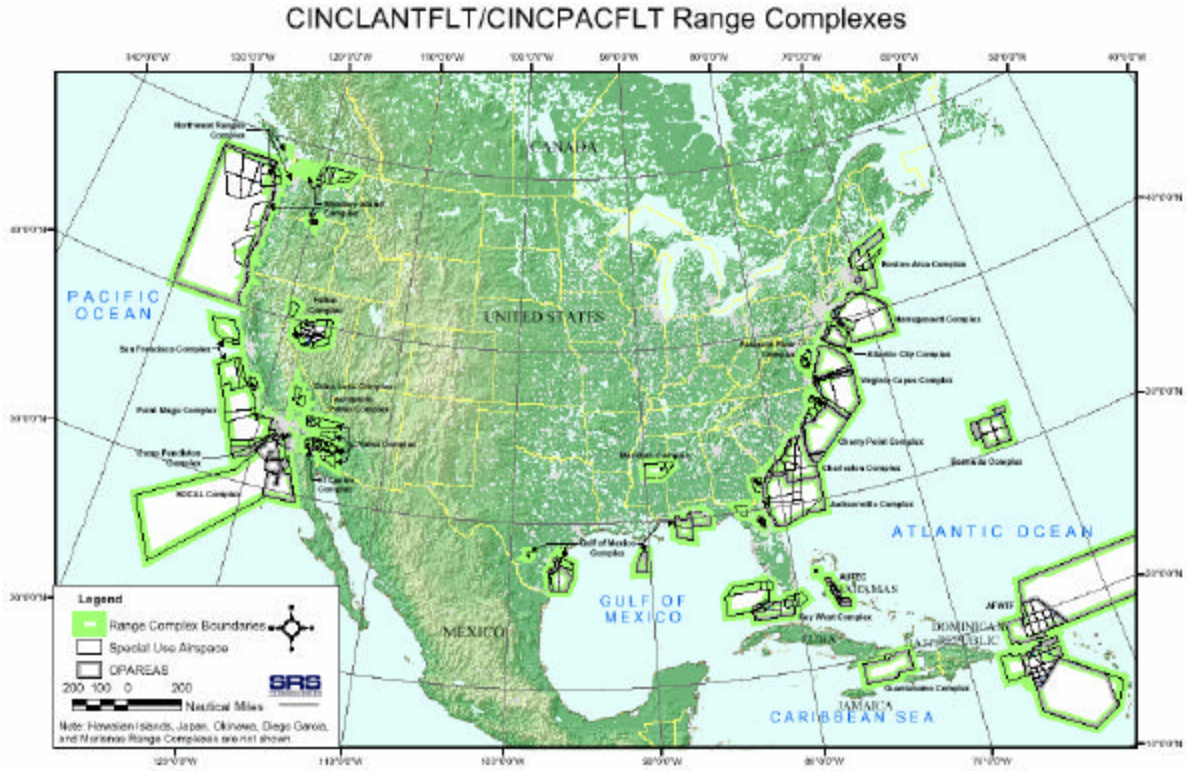

Figure 3-12. Range Complexes

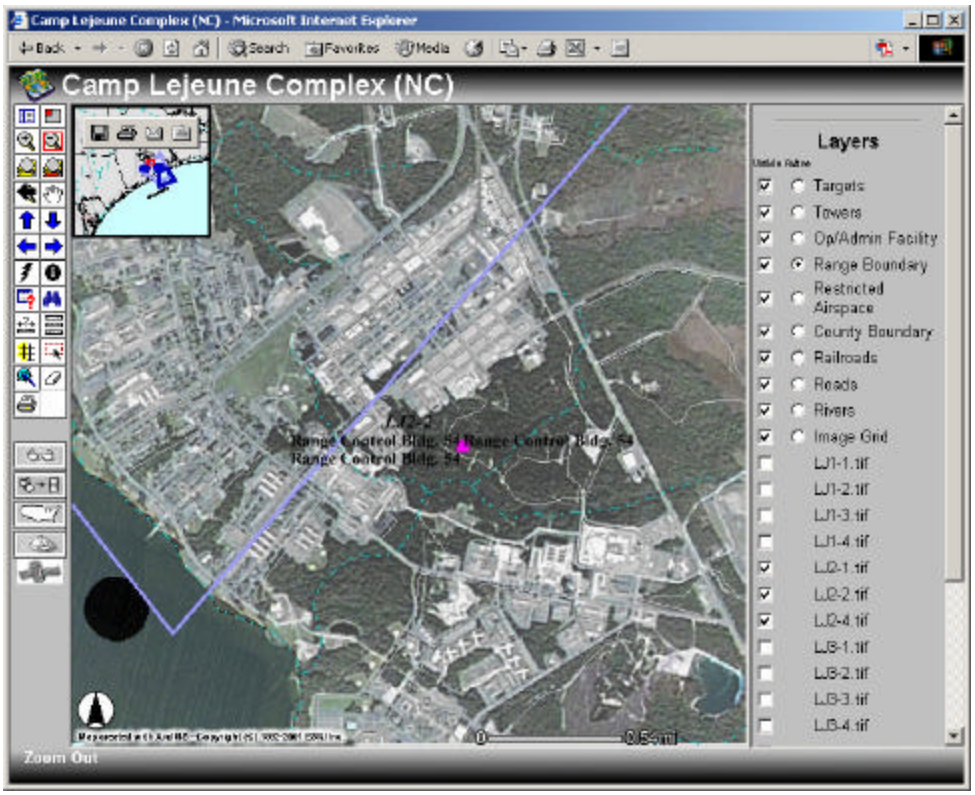

Figure 3-13. Camp Lejeune Ranges

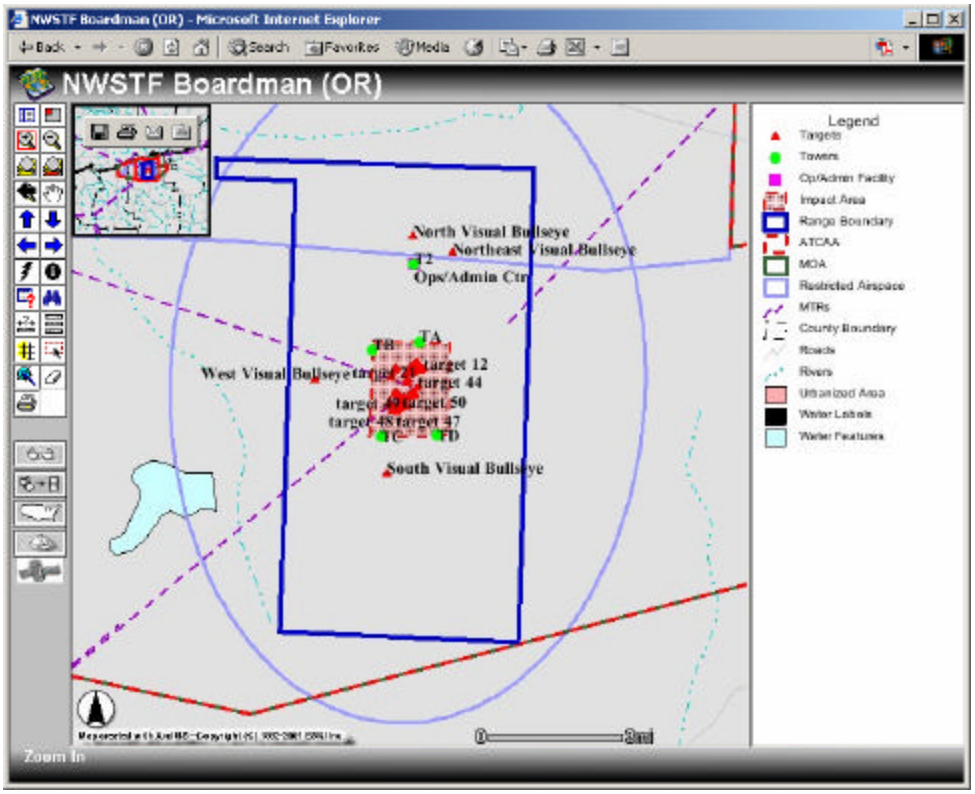

Figure 3-14. Camp Boardman Ranges

NFESC is developing the Explosives Safety Site Planning software with an ESS Toolkit to clean up iNFADS and GIS databases. It utilizes the Quantity Distance (Q-D) Engine that creates the Q-D arcs for site planning and safety issues via a Map Objects program. The current effort is to move to ArcObjects and to utilize the geodatabase of the site. This program is being developed with approval by the DoD Explosives Safety Board.

ESS incorporates imagery and installation databases (real property), then performs calculations for explosives safety arcs and identifies explosives safety violations. It can also do "what if" analyses to determine the building damage and casualty statistics for inside and outside of buildings in the pressure zone. Examples of the output are shown in Figures 3-15, 3-16, and 3-17.

The Joint Land Use Study, Program Guidance Manual has addressed some issues in coordinating the AICUZ, Projectile Firing Range Zones, ESQD, Electromagnetic Radiation, and Radiofrequency Interference concerns in working with the local communities.

Camp Pendleton has developed the Training and Range Encroachment Information System (TREIS). TREIS is an "Encroachment Quantification Toolset and Database" that:

- Establishes a quantitative measure of encroachment impacts as a function of training tasks, training areas, and encroachment factors

- Provides range and training area inventory as well as capacity and utilization information

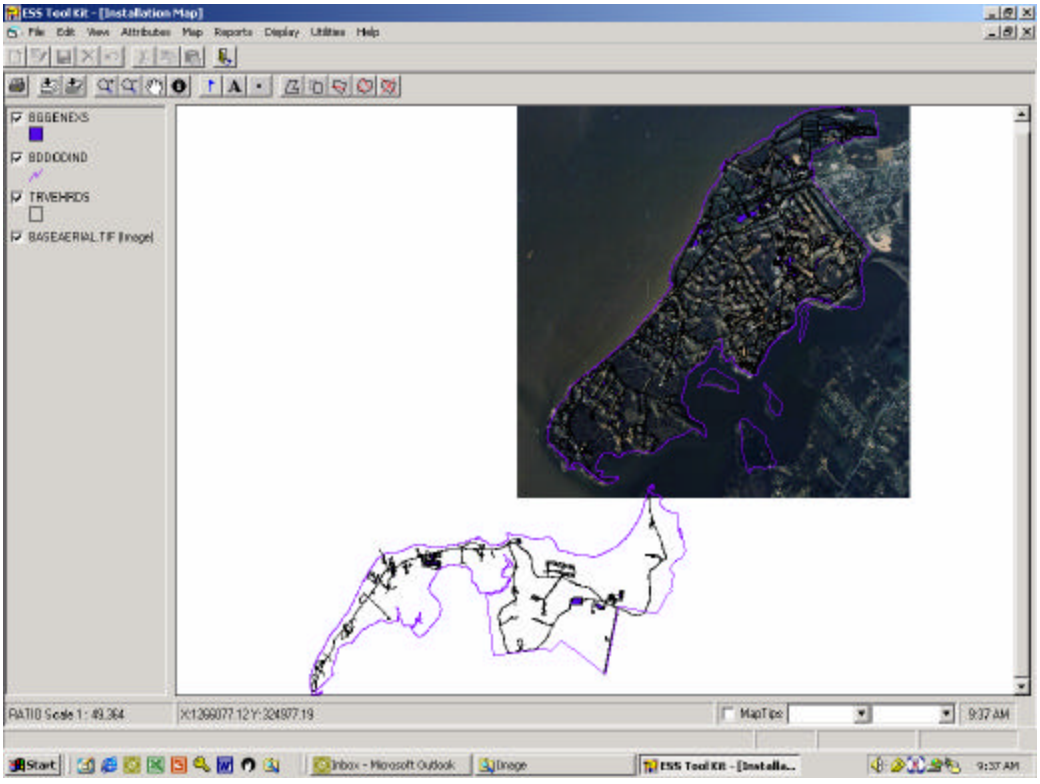

Figure 3-15. ESS Toolkit Installation Imagery and Map

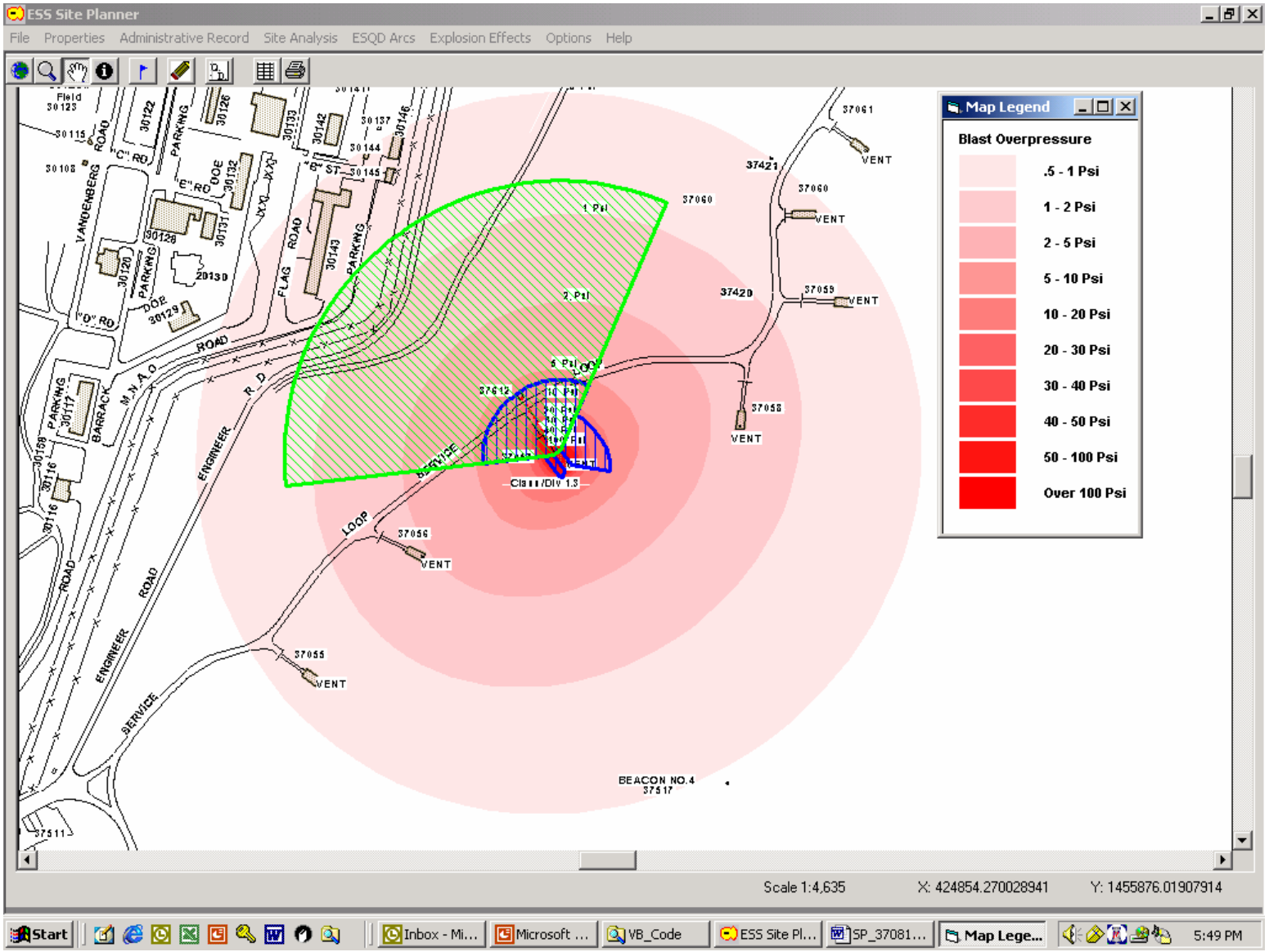

Figure 3-16. ESS Site Planner – Overpressure

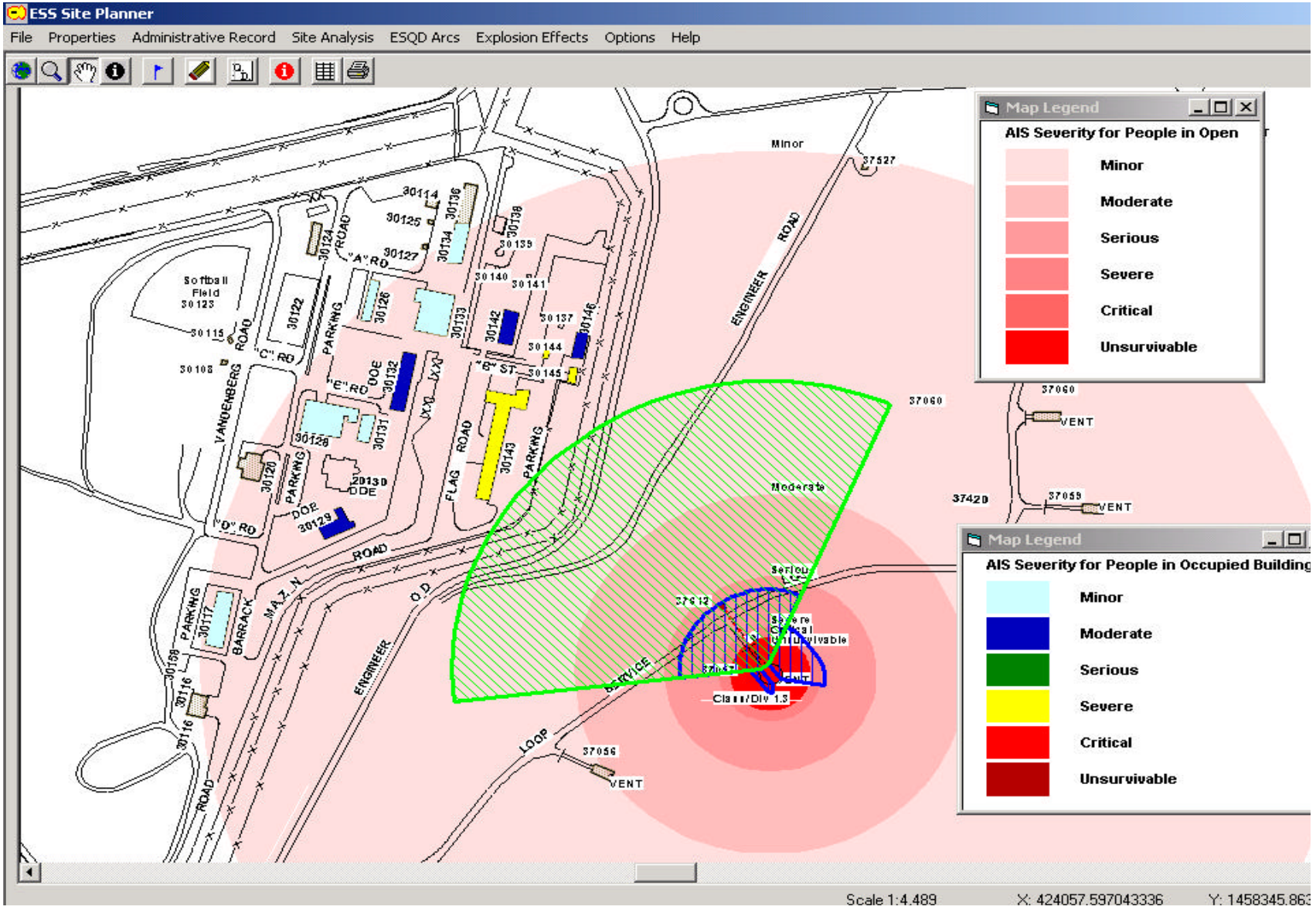

Figure 3-17. ESS Site Planner – Building Damages and Casualty Severity

- Enables future data collection, automated trend analysis and comparison, and reports
- Links directly to the Camp Pendleton Base GIS
- Analyzes data form existing Marine Corps databases (GIS, RFMSS)
- Uses a standard web browser with Camp Pendleton intranet-based open design.

TREIS is a capable analysis tool for commands as it supports troop readiness requirements and identifies potential workarounds from an operational forces viewpoint. Encroachment factors such as endangered species, wetlands, cultural resources, safety, land use, airspace restrictions, water use, noise, urban growth, air quality, and UXO are used to perform trend analysis and measure changes in the use of training areas at Camp Pendleton as well as supporting range management to maximize training value within the constraints of encroachment issues.

Coordination Efforts. Many committees and groups are dedicated to coordinating GIS efforts among services and among fleets. Each has its own agenda and requirements. There are also several user groups throughout the country. Some of the Navy groups are:

Navy Core Mapping Team
Marine Corps Mapping Team
Installation Restoration Mapping
Computer-Aided Detector Design (CADD)/GIS Center
GeoReadiness Integration Team (GRIT)
Homeland Defense Foundation Layer Data Store (HIFLDS)
National Image and Mapping Association (NIMA)
Homeland Security Working Group
GeoSpatial One Stop

3.7.4 Undersea Cables. The Navy's vast array of undersea cables, estimated to comprise 40,000 lineal nautical miles of installed cable, are used for a variety of applications including surveillance, communications, at-sea training, and others. Many of these cables are located on ranges that directly or indirectly support range operations, while others pass through ranges, supporting Navy and other federal agency/departmental operations. Existing cables require maintenance, repair and upgrading, and advancing technology requires installation of new cables. Regulatory requirements have become increasingly stringent and complex with respect to undersea cables, primarily in response to the increase in commercial installation of communications cables and the appurtenant increase in awareness of environmental consequences due to these cables by regulators. The Navy and other federal entities have been required to conform to these requirements, which have proved increasingly burdensome. For instance, blocked planned installation routes, requiring the addition of unplanned effort, has resulted in project cost increases ranging from 20% to 40% in recent years. Navy projects, such as the FOCUS Cable Repair and Survivability Test Areas (STARS), are being subjected to increased regulatory constraints. If not addressed, the new and evolving regulatory constraints could substantially impact Navy operations and range readiness and sustainability.

Besides installation and maintenance/repair of existing cables, removal/abandonment of existing cables is of particular concern for the Navy because many cables are reaching the end of their useful life, whereas others are located in ranges of closed facilities or are slated for closure. Current Navy and industry practice is to abandon in-place, out-of-service seafloor cables. However, due to the increased awareness by the regulatory community, the Navy is being directed to remove out-of-service cables before new cables can be installed, thus impacting mission readiness. The increased compliance and permitting requirements for new Navy seafloor cable projects significantly increases the time to complete a new installation.

Abandonment of undersea cables also raises long-term liability issues for the Navy, particularly if environmental considerations are not adequately addressed up front. Cables in nearshore environments often traverse reefs where corals and other organisms overgrow cables, essentially encapsulating them to become a structural element of the reef. Some view the presence of any man-made structures in a natural environment, including cables, as inherently "bad," and that they must be removed when their service lives are complete; such views further the arguably arbitrary, increasingly stringent regulatory requirements. It is intuitively obvious that removing cables from such environments can do more harm than good, at least in the short term. The issues become murkier when cables are located in degraded reefs, or where cable components contain toxic materials, such as lead sheathing. However, there is little scientific information on the actual environmental impacts of seafloor cables, including their installation, subsequent maintenance, repair, and final disposition. Knowing these potential impacts will allow development of appropriate regulatory requirements and aid in decision-making in all stages of the cable life cycle when based on sound, defensible, scientific judgment.

4.0 Emerging Technology

The Army, Navy, and Air Force have RDT&E programs in support of range sustainability issues. Although some of these programs are limited in scope and usually promote technologies of primary benefit to the component sponsor, some technical information is jointly applied to other service range issues. For example, the Navy is funding via NAVFAC YO817 an effort to determine the environmental effects in marine environments of MC, modeling underwater physical transport of munitions items, and quantification of casing seawater corrosion. Preliminary results from MC degradation studies indicate that saltwater and freshwater dissolution and partitioning are very similar, lending support to not only Navy marine range characterization, but also to fate and effect modeling for Army/Air Force ranges encompassing streams, ponds, lakes, and estuaries.

Two programs providing major funding initiatives to DoD's Sustainable Range initiative are SERDP and ESTCP. These programs solicit and fund science and technology solutions from DoD and other government agencies, as well as corporations and academia.

4.1 Threatened and Endangered Species

Baseline Threatened and Endangered Species Inventories and Research (Army): The project objectives are to develop protocols for the inventory and monitoring of TES. Additionally, a reduction in cost of compliance with regulatory standards is expected. Project is expected to be completed in FY07.

Reducing Impacts of Threatened and Endangered Species on Military Readiness (Army): The project intends to reduce impacts to readiness by providing needed information to regulators and military land managers and using the information to mitigate impacts to TES species. For example, the project is studying the effects of noise, smokes and obscurants, and maneuver operations on the red-cockaded woodpecker. By FY08 the Army will have the ability to quantify impacts from military training and land management and identify mitigation plans for select TES.

Acoustic Monitoring of Threatened and Endangered Species in Inaccessible Areas (SERDP CS-1185): Large parcels of known or suspected threatened species are on military installations that are inaccessible to ground personnel. Traditional ground-based surveys can not be completed in these areas. This project will develop an airborne monitoring system for taking a census of acoustically active species from the air. This pilot project began in FY02 and is ongoing.

Impacts of Military Training and Land Management on Threatened and Endangered Species in the Southeastern Fall Line/Sandhills Community (SERDP CS-1302): The goal of this research is to develop methods to evaluate effects of military training and land management activities on the sustainability of fall line sandhills habitats and TES in the southeastern United States. The project began in FY02 and is ongoing.

The Effects of Aircraft Overflights on Birds of Prey (SERDP CS-89): This research effort examined the lack of conclusive results as to the effects of aircraft overflights on birds of prey. The effort obtained baseline noise effects data over a three year monitoring effort. The research tested the previously untested interim Air Force dose-response model used for predicting aircraft noise effects on raptors. The model was incorporated into the Assessment System for Aircraft Noise (ASAN) model used in DoD environmental impact analysis. Researchers developed an animal noise monitor (ANM) for remote, accurate assessment of noise exposure levels. The project was completed in FY97.

Ecological Biomarkers: Monitoring Wildlife Fauna at DoD Installations (SERDP CS-244): The project addressed a need to monitor fauna in munitions use areas to assess possible adverse impacts from chemical exposures. Fauna was monitored using multiple biomarkers developed by the researchers to quantitatively assess ecological impacts from munitions-related chemical exposure. Biomarkers are used to assess ecological impacts by monitoring physiological, biochemical, and molecular changes in organisms. Among the many munitions compounds examined, the project demonstrated trinitrobenzene (TNB) is less hazardous as previously believed. TNB's cleanup level of 960 ppb is overly conservative and can be raised up to 600-fold according to the researchers. The project was completed in FY97.

Threatened, Endangered, and Sensitive Resources (SERDP CS-507): The increasing number of TES species on military lands is compromising mission readiness. CS-507 objective was to provide guidelines, methods, and evaluation techniques for TES management and mitigation. The scientists developed 18 faunal species profiles for species found in the southeastern United States. The profiles and information developed from community management reports were used to complete a prototype TES Regional Management Plan for the southeastern U.S. The project was completed in FY99.

Assessment of Training Noise Impacts on the Red-Cockaded Woodpecker (SERDP CS-1083): Three seasons of military-related noise impacts to the endangered Red-Cockaded Woodpecker (RCW) were evaluated for this project. The data collected was used to develop dose-response relationships and assess noise impacts at the individual and population level. Data generated from the BNOISE and SARNAM noise models along with training data from Fort Stewart indicates training noise has no significant impact on the reproductive success of the RCW. This effort was completed in FY01.

Methods for Assessing the Impact of Fog Oil on Availability, Palatability, and Food Quality of Relevant Life Stages of Insect Food Sources for TES (SERDP CS-1262): The objective of this study is to provide a cost-effective method for quantifying potential impacts from fog oil on the food base (pray) of TES on DoD training lands. The method will quantify population dynamics and food source value (availability, palatability, nutritional quality) of insect fauna in areas subjected to fog oil smoke. The effort is intended to replace the need for field assessments by reproducing impacts to TES pray in the laboratory. Project began in FY02 and is ongoing.

Toxicological Effects of Smokes and Obscurants on Aquatic Threatened and Endangered Species (SERDP CS-1332): Military training with smokes and obscurants (S&O) in areas occupied by TES species can have adverse impacts to TES and their habitats. The project is studying direct and indirect effects on aquatic TES from field deposition of the five most common S&O. The effort will provide needed ecorisk information for species relevant to military lands that use S&O. The project began in FY03 and is ongoing.

4.2 Munitions Constituents (Operational Ranges)

4.2.1 Munitions Constituents. Efforts are under way to develop and use artillery, munitions, ordnance, propellants, and explosives that have little impact to the environment. However, there will not be acceptable substitutes for many weapons systems. MCs in use today will continue to be used in the future. Therefore, it is important that the MCs being generated at ranges today are better understood because they will continue to be released at operational ranges.

Characterization. Several research and demonstration programs will provide results to enable accurate characterization of firing ranges. Examples of ongoing projects expected to provide necessary data include:

- UXO corrosion source term data for terrestrial ranges
- Characterization of low- and high-order detonations
- Dud and low-order rate database
- Degradation of underwater ordnance and explosives
- Determination of existing data regarding physiochemical and toxicological properties for military unique compounds.

Fate and Transport. Testing and research on various aspects of fate and transport models is ongoing and will continue. For example, the Army is currently performing research through 2005 to determine the effects of transport properties (i.e., retardation factor [Rf] 4). The data will undoubtedly be incorporated into ARAMS.

4.2.2 Characterization and Monitoring

Encapco/Depleted Uranium (Navy): The project's original purpose of soil stabilization was changed to include depleted uranium (DU) site characterization. Four characterization methods were investigated for locating DU-contaminated sites at China Lake, CA. Aerial survey techniques and traditional walkover surveys were performed. Development of a rapid analytical method for screening samples will be generated from the project. Project is ongoing.

Trace Analysis of Perchlorate in Environmental Samples (Navy): This effort was initiated to develop an analytical method capable of measuring trace levels of perchlorate

in complex matrices such as soils and tissue from potential ecological receptors (e.g., vegetation, fish). Naval Surface Warfare Center Indian Head Division is developing the analytical method. It detects perchlorate in the low ppb range and is useable in samples having interference issues. Project is ongoing.

Field-Portable X-Ray Fluorescence (FP-XRF) Determination of Metals in Post-Blast Ordnance Residues (ARMY): Field portable analyzers for MCs are especially useful on large areas of contamination at most range areas of concern. The Army evaluated the analyzer for determining soil metal levels generated post-blast from ordnance items. Most of the post-blast residue was lead, iron, copper, and zinc. Items included M67 hand grenades, 60-mm and 81-mm mortar projectiles, 105-mm howitzer projectiles, mines, and C4 blasts. Measurement accuracy of the instrument as compared to analytical labs was found to not differ significantly when concentrations were above the FP-XRF's detection limits. Project is complete.

Sampling for Explosives Residues at Fort Greely, Alaska–Reconnaissance Visit July 2000 (Army): This effort was implemented to identify possible munitions contamination and evaluate the potential for surface water and groundwater contamination. Characterization was difficult because of the large (85,042-acre) impact area. Discrete, composite samples were taken from areas on the range having evidence of range use. Evidence included cratering, pieces of munitions, or a designated firing point. Conclusions drawn were that low-order detonations and areas of heavily used firing points near groundwater recharge areas are the greatest potential threats to surface water and groundwater. Project is complete.

Estimates for Explosives Residue from the Detonation of Army Munitions (Army): Explosive residue from high order detonation in a snow covered area were sampled and analyzed for explosives. The Army live-fire and blow-in-place munitions used were mortar rounds, howitzer rounds, hand grenades, 40 mm rifle grenades, C4, land mines, a torpedoes, and a shaped demolition charge. Results were live-fire, high-order detonations residues contained much lower levels of munition constituents than the blow-in-place residues. Project is complete.

On-Site Processing and Subsampling of Surface Soil Samples for the Analysis of Explosives (Army): An on-site sampling approach to reduce variance and develop a sampling protocol was completed under this project. The approach takes a subsample of collected range soil samples after they are ground up and mixed on-site. Results from use of the protocol were successful in ranking explosive residue concentrations associated with a specific military training activity. Project is complete.

Study of Five Discrete Interval-Type Groundwater Sampling Devices (Army): Five technologies were evaluated for their ability to recover representative samples of VOCs, explosives, pesticides, and metals. Project is complete.

Guide for Characterization of Sites Contaminated with Energetic Material (Army): This project produced a guide for relevant characterization at sites contaminated with

energetic material. The guide has protocols for many of the different types of contamination generated from the array of munitions used for training. Project is complete.

Field Gas Chromatography/Thermionic Detector System for On-Site Determination of Explosives in Soils (Army): The Army developed a field analyzer for several nitro compounds found in contaminated range soils. The system was verified by comparison to existing methods through the EPA's Environmental Technology Verification (ETV) Program. The field unit can measure nitroaromatic, nitramine, and nitrate ester explosive compounds. Project is complete.

Development of a Field Method for Quantifying Ammonium Picrate and Picrate Acid in Soil and Water (Army): This project resulted in a method for preparation and analytical quantification of ammonium picrate and picrate acid in either water or soil. The method detection limits were determined to be 1.3 mg/g for soil and 3.6 mg/L for water samples. Project is complete.

Underwater Ordnance Casing Corrosion Research (Navy): This project is developing munitions constituent release rates for specific contaminants. Project is ongoing.

Integrated Automated Analyzer for Monitoring of Explosives in Groundwater (SERDP CU-1297): The product of this project is a portable analytical system for cost-effectively characterizing military facilities with explosive contaminants. The project was completed in FY02.

Novel Technology for Wide-Area Screening of Explosive-Related Compounds-Contaminated Soils (SERDP CP-1228): This project responds to the need to characterize the vast amount of DoD land suspected of having explosives-related compounds (ERCs) on and near the soil. This project is focusing on the ERCs emanating from land mines. The effort will evaluate traditional soil sampling/detection methods to their wide-area screening technique. The project was completed in FY02.

A Predictive Capability for the Source of Terms of Residual Energetic Materials from Burning and/or Detonating Activities (SERDP CP-1159): The goal of this project is to develop a source characterization model (SCM) for DoD munitions usage that can be coupled to existing fate and transport models. The SCM will include chemical data and emission factors from munitions use. The project began in FY02 and is ongoing.

Distribution and Fate of Energetics on DoD Test and Training Ranges (SERDP CP-1155): This project is evaluating the impacts of residue generated from live-fire training with munitions and explosives. Impacts from soldier training at Fort Bliss, Texas, from C4 detonations were determined to generate significant explosives residuals. Also, it was determined that judgmental, composite sampling is superior to grid sampling techniques. At the Canadian Forces Base, Shilo, Manitoba Canada, energetic materials found in soils were relatively low. Soil partitioning tests showed pentaerythrito tetranitrate (PETN) and tetryl degrade in surface and aquifer soils. This effort is providing needed data for

estimating energetic source terms, protocols for contaminant characterization, and fate and transport process descriptors for energetic residues. Project is ongoing.

Enhanced Electromagnetic Tagging for Embedded Tracking of Munitions and Ordnance During Future Remediation Efforts (SERDP PP-1272): The objective of this project is to attach radiofrequency (RF) tags on ordnance before use. Assuming the tag survives ignition and impact, it will give off an RF signal that can be used to readily retrieve UXO and MCs. The project began in FY02 and is ongoing.

Rapid Detection of Explosives and Other Pollutants (ESTCP CU-28): Using an existing biosensor developed by the Naval Research Laboratory, this project used the biosensor for testing soil and water samples with TNT and RDX contamination. The sensor was incorporated into a portable device (FAST 2000) for rapid measurement on-site. Demonstrated detection levels were at the part per trillion level. Project was completed in FY97 and was transitioned to ESTCP (CU-9713).

Detection and Measurement of Explosives in Groundwater Using In Situ Electrochemical Sensors (ESTCP CU-1220): The objective of this project is to develop sensors to measure TNT, RDX, HMX, tetryl, and nitrocellulose in groundwater. The sensors are to be used in situ, capable of replacing conventional methods, and have detection levels in the 20 – 50 ppb range. Benefits are reduced long-term monitoring costs and continuous sampling capabilities. The electrochemical sensors measured TNT, TNB, and tetryl down to levels of 50-100 ppb. HMX, RDX, and nitrocellulose were in the 1-2 parts per million (ppm) range. However, interferences from other contaminants and the necessity to remove oxygen before measurement of the nitroamine compounds HMX and RDX limits the usability of the sensors. This one-year effort was completed in FY01.

Long-Term Monitoring for Explosives-Contaminated Groundwater (SERDP CU-1298): This project performed a proof-of-concept demonstration for the detection of trace amounts of TNT and related explosives in groundwater in near real time. The project was completed in FY02.

Portable Surface-Enhanced Raman Instrument for Explosives Monitoring (ESTCP CU-9917): Goal of demonstration was to validate the ability of a field portable surface-enhanced Raman (SER) analyzer for monitoring explosive compounds. The SER analyzer has the ability to analyze explosive-related compounds at trace levels (few micro-liters). The instrument could be used for groundwater sampling, process stream monitoring, and in situ using the cone penetrometer. The project was completed in FY02.

Explosives-Detecting Immunosensors (ESTCP CU-9713): The effort was to demonstrate the efficacy of immunosensors for on-site characterization of TNT and RDX in soil and groundwater. On-site characterization reduces cost, provides real-time data, and expedites the remediation process. Two technologies were evaluated: the Analyte 2000 Fiber Optic Biosensor (FOB) and the FAST 2000 Continuous Flow Immunosensor (CFI). Both technologies experienced matrix interference. Both technologies need further development. The project is complete.

Applied Innovative Technologies for Charaterization of Explosives-Contaminated DoD Building Foundations and Underlying Soils (ESTCP CU-0130): The production, loading, handling, and storage of explosives have explosives beneath their foundation at unacceptably high levels. There are no full-scale technologies for nondestructive, in situ characterization of contaminants around or under buildings or hard-to-reach areas. This project demonstrated the characterization capabilities of (1) colorometric field tests, (2) Raman spectroscopy, and (3) on-site gas chromatography/electron capture detector (GC/ECD). Munition constituents of concern were nitroglycerine (NG), nitrocellulose (NC), dinitrotoluene (DNT). Project is complete but results and demonstrated benefits are unknown.

Naval Shoreside Ordnance Environmental Survey (Navy): The Navy conducted a survey of 83 Navy and Marine Corps to determine the highest priority needs for sustainable operation of ordnance uses in the areas of manufacturing, storage, use, in-service engineering, or nonmilitary disposal of ordnance and energetic materials. Survey results identified 69 separate concerns worthy of research. Environmental concerns were identified as falling into six major focus areas: (1) Process manufacturing, (2) OB/OD, (3) remediations, (4) wastewater treatment, (5) recycling, reclaiming, and reuse (R3), and (6) inerting the material. Project is complete.

4.2.3 Fate and Transport

Land Rehabilitation (Army): Range training activities can cause erosion and produce sediments. The objective of this project is to develop models to support planning, design, execution, and management of land rehabilitation and maintenance activities. Project is ongoing.

Stability of CL-20, TNAZ, HMX, RDX, NG, and PETN in Moist, Unsaturated Soils (Army): The stability of several energetic compounds was evaluated in moist, unsaturated soils from three military training ranges. The compounds studied were CL-20 (hexanitro-hexaazaisowurtzitane), TNAZ (1,1,3-trinitroazetidine), HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrzocine), RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), NG (nitroglycerin), and PETN (pentaerythritol tetranitrate). Half-lives for each compound were determined and ranged from less than a day for TNAZ and NG up to 2,310 days for HMX. Project is complete.

Environmental Fate and Transport of a New Energetic Material, CL-20 (SERDP CP-1254): CL-20 is being considered for replacement of existing propellants and explosive materials. This project addresses potential environmental impacts for the energetic material. Specifically the project objectives are to (1) investigate transport and biotic and abiotic degradation of CL-20; and (2) study the lethal and sublethal effects of CL-20 on terrestrial higher plants, soil invertebrates, soil microorganisms, and avian and aquatic species. Ongoing in FY02, this project is at the bench scale.

Factors Affecting the Fate and Transport of CL-20 in the Vadose Zone Groundwater (SERDP CP-1255): This project examines the characteristics of the environmental fate and reactivity in subsurface sediments by focusing on the identification and quantification of geochemical and microbial reactions of CL-20. Project began in FY02 and is ongoing.

Environmental Fate and Transport of a New Energetic Material, CL-20 (ESTCP CP-1256): CL-20 is being considered for wide application by DoD for military munitions. To avoid future environment problems the new material fate and transport knowledge is needed. Data of the physicochemical, biochemical, and ecotoxicological properties are needed to predict CL-20's fate, transformation, transport, and environmental effects. This project will (1) develop analytical methods to measure degradation products in soil/water systems, (2) determine K_{ow}, K_d, K_{oc}, K_h, and water solubility, and (3) conduct preliminary ecotoxicological tests. Project began in FY02 and is ongoing.

Measurement and Modeling of Energetic Material Mass Transfer to Porewater (SERDP CP-1227): Training and testing on DoD ranges leaves unreacted energetic material on and in near-surface soils. Transfer of contaminants from explosive detonation residue to soil porewater initiates subsurface transportability and subsequent soil and groundwater contamination. This project is using laboratory measurements and numerical simulations to mimic mass transfer caused from weather cycles. A predictive solute transport simulation model will be developed to assess impacts from solid phase energetics. This is a bench-scale project that may transfer to a second phase to evaluate the most significant parameters and factors toward transfer to the environment. The effort began in FY01 and is ongoing.

Impacts of Fire Ecology Range Management on the Fate and Transport of Energetic Materials on Testing and Training Ranges (SERDP CP-1305): Fire Ecology Range Management (FERM) or prescribed burning is a common range management practice. The objective of this project is to examine the impacts to energetic residuals from FERM (Figure 4-1). The approach is (1) the laboratory examination of the rate of decomposition of soil-associated energetics with respect to temperature, (2) define relationships between energetic residuals and range vegetation, and (3) determine the impact of burned energetic residuals to surface soils and runoff using test plots. This project began in FY02 and is ongoing.

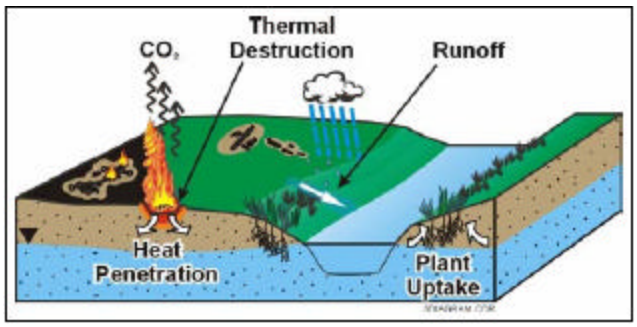

Figure 4-1. Model of Energetic Residuals Impact Soils and Water Bodies

Assessing the Impact of Maneuver Training on NPS Pollution and Water Quality (SERDP CP-1339): The project will assess the surface water quality impacts from major sources of NPS pollution from maneuver training. Specifically, erosion from upland training areas and channel erosion at stream crossing sites will be assessed (see Figure 4-2). The project is ongoing.

Figure 4-2. Training Operations Cause NPS Pollution in Arid and Semiarid Regions

4.2.4 Mitigation Measures

Electrokinetic Remediation of Contaminated Soils (Army): Many ranges have heavy metal contamination. This ex situ project is using electrokinetics to remove cadmium, chromium, and lead from excavated grenade range soils. Remediation should have begun and ended in FY04. A primary goal is to reduce metal concentrations below regulatory limits for beneficial reuse.

Enhanced Alternatives and In Situ Treatment Technologies for Explosives, Organics, and Solvents in Groundwater (Army): The project is a demonstration of five remedial alternatives for cost-effective groundwater treatment of explosives and other organic contaminants. RDX is the representative explosive throughout the project. In situ biological degradation is the first of four technologies tested. Zero-valent iron wall and in situ chemical oxidation technologies will follow. Finally, in situ direct current power and a method for nutrient delivery in adverse geological conditions will be examined. Project is ongoing.

Innovative and In Situ Treatment Technologies for Soils Contaminated with Inorganics (Army): The project focuses on heavy metals and SAR lead, in particular. In FY02, potential techniques for placing sorptive iron and manganese oxide barriers in the subsurface for interception of heavy metals in groundwater were identified. Phyto-technologies (stabilization/extraction), in situ electrokinetic metal extraction, and chemical treatment (active and passive) at metal-contaminated SAR sites will be explored. Project is ongoing.

Treatment Techniques for Wastewaters from Munitions Production (Army): Munitions production is required for overall military readiness and for live-fire on testing/training ranges. The Army does not have cost-effective treatment technology to adequately treat wastewater generated during the production of munitions. By FY04, this effort will investigate the treatment of energetic compounds under anaerobic biological conditions; destruction of ordnance compounds with sonolytic/photolytic technology; and removal of process by-products using reductive electrochemical treatment.

Use of Military Demolition Explosives in a Remediation Project (Army): Control of surface and subsurface contaminated water on ranges is necessary to prevent off-site migration. This is the case at an active range on Fort Richardson, Alaska. The impact site is an estuarine salt marsh bordered by bluffs. The problem is the persistence of white phosphorus in areas containing craters. Pumping the contaminated water is the primary method of removing contaminated water from the craters. However, certain areas are not amenable for pumping because of UXO and soft ground, yet they still need to be drained. The Army has turned to explosives to gain access to the problem areas in order to recover the water. This was a nine-year effort and is complete.

Encapco/Depleted Uranium (Navy): One aspect of this multitasked project was the demonstration of DU-contaminated soil from China Lake for ultimate treatment, disposal, and management. Regulatory issues redirected Encapco's soil stabilization technology for metals, organics, and radionuclide-contaminated soils to the laboratory and field demonstrations. The goal is to reduce off-site migration of contaminated soils. Project is ongoing.

Electrochemical Oxidation of Energetic Waste (Navy): Technology is an alternative for open-burning as a means of explosive treatment. Cerium-Mediated Electrochemical Oxidation (MEO) was investigated by NFESC to determine the feasibility of MEO and assist with implementation. Results indicate technology is not ready for implementation. Project is complete.

Molten Salt Oxidation (MSO) Technology (Navy): Prior to this project a MSO system treating energetic material was operational but had limited explosives feedrates. The Navy needed ability to increase feedrate of energetics. The original 6-inch MSO was evaluated for scale up to 12-inch MSO. The technology lowers overall cost of explosives disposal and environmental damage from methods such as open-burning/open detonation. Project is complete.

Continuous Treatment of Low Levels of TNT and RDX in Range Soils Using Surface Liming (Army): There are concerns of potential groundwater contamination from TNT and RDX generated during training and testing on range lands. Samples of shallow soils containing MCs at a hand grenade training range were used to test agricultural lime application to hydrolyze residual energetics (including TNT, RDX, HMX, and 2,4-DNT). Results indicate lime could be used to destroy all the TNT and most of the RDX. Project is complete.

Engineering Transgenic Plants for the Sustained Containment and In Situ Treatment of Energetic Materials (SERDP CU-1318): The purpose of this project is to investigate containment of explosives at training ranges. Fundamental and applied studies of genetically engineered plants will be conducted to develop plants that can contain and degrade energetic materials on testing and training ranges. Ultimately, the project intends to develop a toolbox of plants with unique abilities to uptake, contain, and degrade MCs, especially TNT and RDX. Project is ongoing and started in FY02.

Fe(0)-Based Bioremediation of RDX-Contaminated Groundwater (SERDP CU-1231): Because of its persistence, toxicity, and high mobility in aquifers, cleanup of RDX sites is challenging. Current practices may be effective but are not cost-effective. This project will develop a new and efficient method to remediate RDX-contaminated aquifers. The technique uses chemical reduction with an Fe(0) barrier followed with in situ bioremediation. Project is a follow on effort from SERDP SEED program. Project is ongoing and began in FY01.

Genetic and Biochemical Basis for the Transformation of Energetic Materials (RDX, HMX, TNT, 2,4-dinitrotoluene [DNT]) by Plants (SERDP CU-1319): This project uses the ability of plants to treat energetic compounds at testing and training ranges. However, phytoremediation is limited by plant toxicity to these compounds. The overall goal is to construct a genetic and biochemical knowledge base for the transformation pathways of energetic materials by exploiting the fact that these chemicals are phytotoxic at low concentrations (5 ppm for TNT and 20 ppm for RDX). Project is ongoing and began in FY02.

Identification of Metabolic Routes and Catabolic Enzymes Involved in Phytoremediation of the Nitro-Substituted Explosives TNT, RDX, and HMX (SERDP CU-1317): The objective of this project is to explore the metabolic routes and the catabolic enzymes involved in the transformation and detoxification of the nitro-substituted compounds. Satisfactory results will lead to phytoremediation and containment of these compounds by hybrid poplar trees. Project is ongoing and began in 2002.

Immobilization of Energetics on Live-Fire Ranges (SERDP CU-1229): The objective of this project is to identify and evaluate low-cost additives that can be applied at active live-fire ranges to prevent the migration of energetic compounds to underlying groundwater. Sorbents will be evaluated as binding agents for carbon sources and materials needed to promote biodegradation. The project started in FY02 and is ongoing.

In Situ Bioreduction and Removal of Ammonium Perchlorate (SERDP CU-1162): Microbial reduction of perchlorate is known. This project provided a better understanding of the microbiology involved in this reduction and removal. Additionally, the work has assisted in the development of protocols and molecular tools required for the modeling and application on in situ bioremediation strategies. The project is ongoing and began in FY00.

In Situ Bioremediation of Perchlorate-Impacted Groundwater (SERDP CU-1163): This project examined the processes of biological reduction of perchlorate. Laboratory microcosm studies evaluated the ubiquity of perchlorate-degrading bacteria in impacted groundwater. Next, small-scale field pilot testing at one site was performed to demonstrate that perchlorate can be degraded under field conditions. The project began in FY00 was completed by FY01.

In Situ Bioremediation of Perchlorate-Impacted Groundwater (SERDP CU-1164): Remediation of perchlorate contaminated groundwater could cost DoD billions of dollars. Project complements CU-1163 and was designed to assess in situ bioremediation in varying geochemical environments and generate field data for a larger scale demonstration. Results showed perchlorate can be reduced from 660 mg/L to 0.018 mg/L in a short timeframe. Project was completed in FY01.

Bioremediation of Hydrazine (SERDP CU-118): The research provided data needed to develop a biologically mediated process for in situ remediation of hydrzine, a common groundwater contaminant at DoD, NASA, and numerous civilian facilities. Results showed the biocatalyst diazoluminomelanin (DALM) can be used to remediate hydrazine spills without generating harmful degradation products. Project was completed in FY97.

Explosives Conjugation Products in Remediation Matrices (SERDP CU-715): This basic research examined the concerns of noncomplete destruction of TNT using various treatment technologies. The study required analytical methods not available at the time. Testing of explosives transformation products in compost and digester sludges were compiled into a report by the U.S. Army Cold Region Research and Engineering Laboratory (CRREL) Special Report. Project was completed in FY98.

Federal Integrated Biotreatment Research Consortium (FIBRC): Flask to Field Initiative (SERDP CU-720): FIBRC was initiated to develop a set of biotreatment processes for cleanup of several classes of contaminants (e.g., PCBs). Biotreatment techniques for explosives contaminated soils and groundwaters are among the four classes or contaminant groups. A fluidized-bed technology for biodegredation of 2,4- and 2,6-dinitrotoluenes in contaminated groundwater was developed. Project began in FY98 and ended in FY01.

Natural Attenuation of Explosives in Soil and Water Systems at DoD Sites (SERDP CU-1043): Use of natural attenuation technology for explosives remediation can be more cost-effective than other treatment technologies. This applied research verified earlier research that extractable TNT levels decrease over time in soil mesocosms. A sampling protocol and parameters for incorporation into existing groundwater models were produced. Three tests were developed to assess microbial degradation potential of TNT and RDX contaminated sites. The effort was completed in FY98.

Fe(0)-Based Bioremediation of RDX-Contaminated Groundwater with Sequential Reactive Treatment Zones (SERDP CU-1176): Zero-valent permeable reactive walls reduce nitrated explosives (i.e., TNT) but create toxic aromatic amine by-products. The

project provided data contrary to the amine by-product concept. It was determined only very high groundwater flowrates and/or low iron loadings within the walls allowed incomplete transformation from the nitrated explosive to benign compounds without amines. The project ended in FY00 and initiated SERDP CU-1232, Remediation of Explosives contaminated Groundwater with Zero-Valent Iron.

Topical Lime Treatment for Containment of Source Zone Energetics Contamination (SERDP CU-1230): This project is investigating the feasibility of treatment and containment of source zone energetics through topical lime application. Research results will determine lime dosing requirements based upon soil type and organic carbon content to prevent subsurface migration. Microcosm studies will evaluate the ability of quicklime, slaked lime, and class C flyash application to destroy RDX and TNT in contaminated soils. The project began and was completed in FY01.

Development and Application of a Flash Pyrolysis-GC/MS Assay for Documenting Natural and Engineered Attenuation of Nitroaromatic Compounds (SERDP CU-1233): This effort will answer the question "Does attenuation of nitroaromatics occur?" and "How can attenuation be converted into an effective, reliable site-remediation technology?" Using a novel suite of chemical and microbiological measurement techniques was intended to develop attenuation criteria by implementing a novel assay. The project began in FY01 and was completed in FY02.

Sequential Electrolytic Degradation of Energetic Compounds in Groundwater (SERDP CU-1234): The objective of CU-1234 is to evaluate abiotic degradation of aqueous-phase energetic compounds exposed to one or more sequential electrically-induced redox zones. Data collected will provide a basis for field scale demonstration of TNT, RDX, DNT, and HMX. It is believed the process will completely degrade aqueous energetic compounds and their intermediate products. This project began in FY01 and is ongoing.

Novel Pathways of Nitroaromatic Metabolism: Hydroxylamine Formation, Reactivity, and Potential for Ring Fission for Destruction of TNT (SERDP CU-1214): Prior research has shown a metabolic pathway that removes the aromatic characteristics of TNT. The goal of this project is to understand fundamental processes of remediation so the process can be carried out in situ. The project was at the proof-of-concept level as of FY02.

Remediation of Explosives-Contaminated Groundwater with Zero-Valent Iron (SERDP CU-1232): This project is providing proof-of-concept that Fe-permeable reactive walls reduce explosives and their degradation products in DoD groundwaters. Factors under observation are (1) whether any products are released from the barrier (Fe) back into the groundwater; and (2) whether complex mixtures of contaminants and/or groundwater constituents would significantly alter long-term performance. The project was completed in FY02.

Sequential Electrolytic Degradation of Energetic Compounds in Groundwater (SERDP CU-1234): This project addresses groundwater treatment of energetic compounds (TNT, DNT, RDX, HMX) and breakdown products. Electrolytic reactors or e-barriers are being evaluated for their ability to abiotically mineralize dissolved-phase energetic compounds in groundwater. As of FY02 the project was at the bench scale.

Enhancement of In Situ Bioremediation of Energetic Compounds by Coupled Abiotic/Biotic Process (SERDP CU-1376): New start in FY04.

Biodegradation of Nitroaromatic Compounds by Stimulating Humic Substances and Fe^{+3} (SERDP CU-1377): New start in FY04.

Groundwater Chemistry and Microbial Ecology Effects on Explosives Biodegradation (SERDP CU-1378): New start in FY04.

On-Range Treatment of Ordnance Debris and Bulk Energetics Resulting from Low-Order Detonations (SERDP CP-1330): This project aims to complete development of a low-cost, fieldable process for decontamination of energetic materials from bulk low-order detonation (LOD) debris. Energetic compounds from contaminated LOD will be separated into solution and inert scrap. The solution with contaminants will be hydrolyzed and thermally treated on site. The project began in FY02 as a bench-scale study and is ongoing.

Demonstration of Anaerobic Percolating Biofilters for Treating Perchlorate in Wastewater Generated During Rocket Motor Testing (ESTCP CP-0403). New start in FY04.

Biologically Active Zone Enhancement (BAZE) for In Situ RDX Degradation in Groundwater (ESTCP-CU 0110): The objective of this demonstration is to validate a methodology for sequential reductive transformation of RDX in groundwater. Transformation occurs through a biologically active zone in the subsurface. The zone is made by adding an agent (e.g., starch) to induce anaerobic conditions and serve as a nutrient source for RDX-degrading microbes. The project began in FY02 and is ongoing.

Comparative Demonstration of Active, Semipassive, and Passive In Situ Bioremediation Approaches for Perchlorate-Impacted Groundwater (ESTCP CU-0219): The project will compare semipassive and active bioremediation approaches; demonstrate the efficacy of in situ bioremediation for perchlorate-impacted groundwater; and generate cost and design information required to design and implement the technology. The project started in late FY02 and is ongoing.

In Situ Bioremediation of Perchlorate in Groundwater (ESTCP CU-0224): The object of this project is to demonstrate in situ bioremediation of perchlorate in a contaminated aquifer using an innovative horizontal flow treatment well. Treatment well system is used to distribute and mix electron donors. Wells are placed in pairs to create a

recirculation cell within a contaminated aquifer. The project began in FY02 and is ongoing.

Edible Oil Barriers for Treatment of Chlorinated Solvent and Perchlorate-Contaminated Groundwater (ESTCP CU-0221): Demonstration of pilot-scale edible oil permeable reactive barriers for enhanced biological degradation will occur at two separate perchlorate plumes and one chlorinated solvent plume at two different DoD installations. Surfactants are added to oil to make an emulsion that is miscible in water. A subsurface barrier is created by injecting the emulsion into standard or direct push wells oriented perpendicular to groundwater flow direction. Project is ongoing.

Perchlorate Removal, Destruction, and Field Monitoring Demonstration (ESTCP CU-0312): The performance of several ion exchange resins and a low-cost, prototype field monitor capable of real time, on-line perchlorate analysis will be demonstrated at the Massachusetts Military Reservation. The systems regenerate the resins. The spent regeneration effluent will be treated using biological and thermal technologies for reuse or disposal. For drinking water applications the permitting process should be easier than biological systems. Project is ongoing.

Permeable Mulch Biowall for Enhanced Bioremediation of Perchlorate in Groundwater at a DoD Facility (ESTCP CU-0427): FY04 new start project.

Evaluation of Potential for Monitored Natural Attenuation of Perchlorate Contaminated Groundwaters (ESTCP CU-0428): FY04 new start.

Field Comparison of Biofouling Control Measures for In Situ Bioremediation of Groundwater (ESTCP CU-0429): FY04 new start.

In Situ Bioremediation of Perchlorate in Vadose Zone Source Areas (ESTCP CU-0435): FY04 new start.

Bacterial Degradation of DNT and TNT Mixtures (SERDP CU-1212): Many DoD installations that manufacture, handle, and store munitions are contaminated with TNT and DNT. The objective of this project is to characterize bacterial strains with the ability to efficiently degrade mixtures of DNT isomers and expand their degradative capability to TNT. The project is ongoing.

Remediation of TNT and RDX in Groundwater Using Zero-Valent Iron Permeable Reactive Barriers (PRBs) (ESTCP CU-0223): This project is demonstrating the use of PRBs for in situ interception and destruction of the explosives TNT and RDX in an aquifer. The field-scale, reactive barrier will be examined for contaminant destruction efficiency, continuity of flow through barrier, and the importance of subsurface microbiology towards explosives destruction within and downgradient of the PRB. The project started late in FY02 and is ongoing.

In Situ Bioremediation of Energetic Compounds in Groundwater (ESTCP CU-0425): FY04 new start.

Treatment of RDX and HMX Plumes Using Multch Biowalls (ESTCP CU-0426): FY04 new start.

Peroxone Treatment of Explosives Contaminated Groundwater (ESTCP CU-9514): The need for improved technology for remediation of groundwater containing explosives led to the development of a Peroxone treatment technology. Peroxone is an advanced oxidation process using ozone and hydroxyle radicals to readily destroy explosive compounds. Peroxone technology was developed by the Army (Waterways Experimentation Station) and demonstrated at Cornhusker Army Ammunition Plant, Grand Island, NE. The field scale technology successfully removed TNT, TNB, NRDX to below target concentrations of 2.0 µg/L at 13 gpm. However, at a more realistic flowrate of 1,000 gpm the large amount of O_3 and OH^- required makes Peroxone more expensive than granular activated carbon or ultraviolet oxidation systems. Project is complete.

Monitored Natural Attenuation of Explosives in Groundwater (ESTCP CU-9518): Monitored natural attenuation (MNA) was demonstrated for explosives remediation of contaminated groundwater at the Louisiana Army Ammunition Plant. Explosives monitored were TNT, RDX, TNT and RDX daughter products, and TNT and RDX by-products using EPA Method 8330. Site characterization, two years of monitoring data, and numerical groundwater model results predicts a reduction in mass over the following 20 years. Costs estimated over a 20-year period are 25 percent and 50 percent less than in situ bioremediation and pump/treat systems, respectively. MNA can be a good alternative at sites where disturbances are undesirable, locations within sensitive habits, and where engineered technologies are not feasible. Concerns over MNA are long cleanup period, significant data requirements, difficulties with undeveloped bioassay techniques and analytical methods. Project is complete.

Phytoremediation of Explosives-Contaminated Groundwater Using Constructed Wetlands (ESTCP CU-9520): A surface flow and subsurface flow (SSF) constructed wetland system was demonstrated for their ability to remove several nitrobodies: TNT, RDX, TNB, HMX, 2AA-DNT,and 4A-DNT. The gravel based subsurface flow outperformed the surface flow wetland and is recommended for application of explosives contaminated groundwater. At influent levels of 3,250 and 9,200 ppb nitrobodies the SSF wetland achieved significant TNT (below 2 ppb) RDX and total nitrobodies to less than 50 ppb. A SSF system sized to meet 200 gpm was estimated to cost $2.06 per thousand gallons for reinjection and $1.78 per thousand gallons for surface effluent discharge. Capital cost estimates were $3,465,000 for surface discharge and $4,125,000 for groundwater reinjection. Project is complete.

Joint Small Arms Range Remediation (ESTCP CU-9513): Control of lead contamination and ricochet from continued use at active SARs is a concern requiring technologies for removing lead and other heavy metals imbedded in the range berms. The technology demonstrated was physical separation and acid leaching of the heavy metals

in berm soils. The system is viable using hydrochloric acid for leaching. 875 tons of berm soil was processed at Fort Polk, Louisiana. Performance objectives of treated soil lead levels below 500 g/kg and 5 mg/L for total lead and TCLp lead concentrations, respectively. The physical separation/acid leaching technology costs $168 per ton, allows recovery of recyclable metals, reuse of the soil to replace berm, and is considered the technology of choice among state regulators for SAR berm soil maintenance and decontamination. Project is complete.

Grenade Range Management Using Lime for Dual Role of Metals Immobilization and Explosives Transformation (ESTCP CU-0216): Metals and explosives accumulating at active grenade ranges can become the source of contamination and off-site migration. This project is demonstrating the combined mitigation measures of lime addition and reactive barriers. The lime application stabilized contaminants reducing their tendency to travel off site. The reactive barriers will treat contaminants migrating off site through the subsurface. The project is ongoing.

Microbial Degradation of RDX and HMX (SERDP CU-1213): Primary objective of this effort is to determine the enzymatic and microbial processes involved in the initial attack on RDX and HMX that leads to rapid autodecomposition. The secondary objective is to conduct similar experiments to determine how these biochemical processes function in model and natural soil systems. The project is ongoing.

4.2.5 OB/OD-Related Issues

Evaluation of the Use of Waste Energetic Materials and Demilitarization of Explosives Stockpiles (SERDP CP-524): DoD has amassed and continually generates a large amount of propellants, explosives, and pyrotechnics (PEP) that cannot be used and need to be properly demilitarized. OB/OD destruction has been a common method to accomplish demilitarization, but generates air emissions, requires a RCRA permit, and is being increasingly scrutinized by regulators. This project studied the possibility of using waste energetic material as a supplement to Number 2 fuel oil used for steam generating boilers. The project showed the blended fuel mixture produces emissions that are sufficiently accurate and repeatable according to EPA guidelines. Only TNT/fuel oil mixtures were chemically incompatible. Project was completed in FY97.

Enzymes for Degradation of Energetic Materials (SERDP CP-1078): As the regulation of OB/OD for explosives destruction and demilitarization, innovative alternatives are needed. This basic research project intends to isolate enzymes for utilization in low-cost systems for the stabilization of destruction of energetics. Researchers have already extracted and isolated an enzyme to degrade TNT into a major intermediate that has many potential industrial uses. In this case, recovery and re-use could make the technology more cost-effective. Project was completed in FY99.

Safe Deactivation of Energetic Materials and Use of Byproduct as Epoxy Curing Agents (SERDP CP-1079): The goal of this project is to develop an alternative to OB/OD to reduce DoD's 700,000 tons of stockpiled energetics. The approaches tested

were two chemical methods to safely treat explosives. Results showed TNT and RDX elimination with the formation of intermediate compounds. Project was completed in FY00.

Recovery and Reuse of HMX/RDX from Propellants and Explosives (ESTCP CP-9708): DoD has a significant need for alternatives to OB/OD destruction of propellants and explosives. The project demonstrated a new process for extraction and recovery of HMX and RDX using mineral acids. A 150 lb/day pilot batch facility was constructed at Fort Wingate Army Depot in Gallup, NM. HMX recovery with the acid showed a $9.75 per pound benefit after sale and reuse, when compared to OB/OD. The low market value of RDX made its recovery uneconomical. The technology is considered viable for HMX and more cost-effective than OB/OD. Project was completed in FY00.

Confined Burn Facility Open Burning Replacement Project (Navy): The Navy intends to provide an environmentally acceptable alternative to open burning at ranges. No other technologies exist to replace open burning. The technology is for range residue demilitarization purposes

4.3 Protected Marine Resources

Determining Source Levels, Sound Fields, and Body Sizes of Singing Humpback Whales in the Hawaiian Wintering Grounds (Navy): The project was initiated to determine directionality and loudness of humpback whales to assess their effectiveness as an advertisement display and vulnerability to masking sounds. The project was initiated in FY02 and is ongoing.

Development and Field Testing of the Digital Whale Tag (DTAG) for Deep-Diving *Odontocetes* (Navy): The Navy initiated this project to help define safe exposure levels for marine mammals exposed to underwater sound. The goal is to learn from the functions and behaviors observed in *Odontocetes* (e.g., sperm whale) from sound testing to be able to estimate the biological significance of the disruptions to *Odontocetes*. The project was initiated in FY02 and is ongoing.

Effects of Sound on the Marine Environment (ESME) and Environmental Consequences of Underwater Sound (ECOUS) (Navy): The objective of this project is to create predictive models and associated software for predicting the effects of underwater sounds on the marine environment. The model has been tested on sites of Navy interest. Project is ongoing.

Marine Mammal Compliance Tools (Navy): This project intends to develop planning and monitoring tools to minimize the frequency and severity of Navy interactions with legally protected marine mammals. Marine mammal occurrence data will be provided by updating the Living Marine Resources Information System (LMRIS). There will be collection of marine mammal abundance data in Navy regions of interest. The project is also investigating the feasibility of detecting and classifying the calls of specific marine mammals using existing sensor systems. Project is ongoing.

Marine Mammal Monitoring Capabilities for the Pacific Missile Range Facility Instrumented Test Range (Navy): The objective of this project is to develop techniques for improving current methods for conducting surveys for marine mammal populations at the PMRF. The goal is to use acoustic monitoring to detect selected whale sounds, statistics of the whale sounds, and when possible, to locate whales. Project is ongoing.

Marine Mammal Monitoring on Navy Undersea Ranges (Navy): The objective of this project is to provide the tools required to monitor marine mammal movement on Navy undersea ranges. Existing range sensors and digital signal processors will be used. Project is ongoing.

Miniature Acoustic Recording Tag to Assess Marine Wildlife Response to Sound (Navy): Acoustic emissions from Navy activities may impact marine wildlife. The objective of this project is to determine the effects of acoustic emissions on marine mammals using easy-to-use acoustic tags. Project is ongoing.

Pinniped Bioacoustics: Auditory Mechanisms, Temporary Threshold Shift, and Effects of Noise on Signal Reception (Navy): Anthropogenic noise affects the signal processing of pinnipeds. This program is obtaining a better understanding of acoustic signal processing in pinnipeds to address impacts of noise on pinniped vocal communication. Project is ongoing.

Prediction of Acoustic Safety Criteria for Marine Mammals (Navy): Various noise phenomena from Navy activities impact the hearing of marine mammals. The objective of this effort is to develop acoustic safety criteria and thresholds for mammals exposed to Navy sound sources. Project is ongoing.

Automated 3D Tracking of Sperm Whales Using Towed Arrays (Navy): This project will produce a passive method for identifying potential effects of seismic and other anthropogenic noise on sperm whale dive times and maximum dive depths. Information collected will be used to develop models of the foraging costs associated with long-term exposures to low-level anthropogenic sounds. Project is ongoing.

Acoustical and Visual Monitoring for Marine Mammals at the Navy's Southern California Off-Shore Range (SERDP CS-1189): Naval operations are conducted in the Southern California Offshore Range (SCORE), a region abundant with marine mammals. Within the SCORE region, this project is comparing methods to monitor marine mammals by (1) aerial surveys (visual), (2) ship-based transect surveys (visual), (3) sonobuoy-based mobile acoustic surveys, and (4) continuous fixed-site acoustic surveys. This is an FY02 ongoing pilot-scale project.

Acoustic Response and Detection of Marine Mammals Using an Advanced Digital Recording Tag (SERDP CS-1188): This project will (1) quantify the probability of passive detection of marine mammals in Navy range waters; and (2) evaluate the

short- and long-term impacts of DoD activities on marine mammals. The project is an ongoing field-scale effort that began in FY01.

Information Technology Tools for Assessment and Prediction of the Potential Effects of Military Noise on Marine Mammals (SERDP CS-1082): This effort developed methods to directly assess and predict the effects of military noise on marine mammals. Accomplishments were the first detailed analyses of Baleen whale ears, the first models of Baleen whale auditory sensitivity, and application of the model to prediction of sensitivity of Baleen whales to DoD sound types. Project was completed in FY00.

Whale Monitoring Using the United States Navy Integrated Undersea Surveillance System (IUSS) (SERDP CS-48): IUSS was used to monitor various marine mammal species. Project was completed in FY98.

Marine Mammal Response to Low Frequency Sound (SERDP CS-1069): This project developed state of the art monitoring and mitigation capabilities for assessing the impacts of manmade low frequency sound on marine environment. Project was completed in FY98.

Predictive Spatial Analysis of Marine Mammal Habitats (SERDP CS-1390) – FY04 new start.

Predictive Modeling of Marine Mammal Density from Existing Survey Data and Model Validation Using Upcoming Surveys (SERDP CS-1391) – FY04 new start.

4.4 Air Pollution

Particulate Matter/Dust Control (Army): The project objectives are to better understand and assess the air pollution impacts of PM emissions generated from Army training operations. The approach is to use existing and develop improved source characterization and modeling to better understand the problem. Once the source is characterized, the Army will develop advanced PM measurement and mitigation technology to limit environmental impacts. PM mitigation and measurement technology is expected in FY05 and regional scale atmospheric models should be completed in FY06.

Contained Combustion Technology for Propellants and Propulsion Systems (Navy): The object of this effort is to reduce environmental emissions from static tests of propulsion systems. Final rocket motor testing was completed in FY02.

Rocket Motor Exhaust Scrubber for Static Firing Operations (NAVY): Static testing of rocket motors generates regulated gases and particulates. There are no known exhaust cleaning technologies and so all pollution generated is emitted to the air. The objective of this project is to develop and demonstrate a technology to remove pollutants from rocket motor testing without adversely affecting the testing data. The strategy is to develop three progressively larger systems for verification. A modified wet scrubber technique is the basis for exhaust gas control. The first has been developed on a small

scale and was successful. A larger model was initiated in 2002 and if successful will lead to a full-scale system. Project is ongoing.

A Field Program to Identify Toxic Release Inventory (TRI) Chemicals and Determine Emission Factors from DoD Munitions Activities (SERDP CP-1197): The objective of this project is to demonstrate a methodology for measuring emissions of TRI chemicals from DoD munitions usage. The method will be used to determine emission factors for quantifying the emissions from munitions usage. Emission factors will be developed for a target list of TRI chemicals emitted at the point of discharge and the point of impact. The measuring instrument is being developed in the laboratory and will be used in the field at Aberdeen Test Center in Maryland. The project began in FY01 and is ongoing.

Adaptive Grid Modeling and Direct Sensitivity Analysis for Predicting the Air Quality Impacts of DoD Activities (SERDP CP-1249): This project's objective was to improve the predictive capability of current air quality models so they can be used to simulate air quality impacts from DoD emissions. A new air quality model incorporating the adaptive grid and sensitivity analysis techniques was developed for prescribed burns at Fort Benning, GA and applied to estimate ozone (O_3) impacts. The adaptive grid provided improved resolution of oxides of nitrogen (NO_x) and volatile organic compounds (VOC) emissions released from the burn plumes, and sensitivity analysis provided the ability to discern the downwind increase in O_3 concentration caused by the prescribed burn from the overall increase in O_3 concentrations caused by all other sources in the region. The project was completed in FY02.

Characterization of $PM_{2.5}$ Dust Emissions from Training/Testing Range Operations (SERDP CP-1190): This project intends to provide users with enhanced ability to characterize, perform EAs, and provide cost-effective dust control measures for particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). Scientifically valid data, emission factors, advanced sampling techniques, and theoretical modeling is included. Better understanding of dust emissions is necessary to increase sustainability of troop operations at arid sites. The project began in FY01 and is ongoing.

Fundamental Studies of Air Emissions from DoD Munitions and Novel Approaches for Their Detection (SERDP CP-1193): This project complements CP-1197 in that it is focused on the need for improved emission data for TRI chemicals generated from the firing and exploding points of munitions during training and testing activities. CP-1193 addresses the difficulty and expense of identifying and quantifying the many TRI chemicals emitted from munitions use. The approach is to use computational fluid dynamics (CFD) models to evaluate chemical reaction fundamentals between emitted compounds and ambient air to evaluate TRI chemical generating pathways and identify TRI compounds that are not generated. Four munition compounds were evaluated: nitrocellulose (NC), nitroglycerin (NG), octagen (HMX), and pentaerythytol tetranitrate (PETN). The benefits include (1) more accurate and less burdensome TRI reporting from improved characterization of energetic emission plumes with respect to volume, constituents, and the distribution of the constituents within the plume; (2) a reduced need for expensive

field emission characterization by developing a process to predict field generated TRI emissions by using the aforementioned models in the laboratory. Project was complete in FY01.

Development of a GIS-Based Complex Terrain Model for Atmospheric Dust Dispersion (SERDP CP-1195): A need exists for accurate measurement of dust dispersed into local and regional airsheds from military activities for determination of compliance with air quality standards. Range-related sources include vehicle and troop maneuvers, use of smokes and obscurants, and controlled burns. The research objectives for this project are to develop a GIS-based dispersion modeling system for use in complex terrain, use the system to estimate range contributions to PM air quality, develop dust generation and fate models for range activities, and help develop dust mitigation strategies. The modeling system is based on a widely used GIS program (ArcView from Environmental Systems Research, Inc. [ESRI]) and will be linked to EPA-approved air dispersion models. Primary benefits to users are (1) the ability to run the appropriate models for specific training/testing activities and then graphically view and analyze the dust impacts; and (2) the capability of providing real-time dispersion estimates for sites maintaining real-time meteorological networks. The latter benefit will enable range managers to alter or relocate activities to minimize particulate emissions. The project is ongoing and began in FY01.

Particulate Matter Emission Factors for Dust from Unique Military Activities (SERDP CP-1399): This is a FY04 new start under development.

Development of Emissions Factors for Particulate Matter, Nitrogen Oxides, and Air Toxic Compounds from Military Aircraft (SERDP CP-1402): This is an FY04 new start under development.

Characterization of Open Burning/Open Detonation Emissions (SERDP CP-247): A common disposal method for demilitarized munitions stockpile is by open burning/open detonation (OB/OD). Air emissions from OB/OD activities are regulated by permit under RCRA regulations (40 CFR 264 Subpart X). Characterization of emissions is required because computer simulations and modeling were unacceptable to regulators. This project is part of a program to develop a system that is fully capable of characterizing emissions produced by all conventional munitions and PEP materials. Its main objectives were to make the OB/OD disposal process more efficient, create an OB/OD database to capture test results and emission factors, reduce environmental impacts of OB/OD, and facilitate the Subpart X permitting process. The project accomplished the main objectives. Test results and emission factors developed and stored in the project database were incorporated into the Munitions Items Disposal Action System Database (MIDAS). Project was completed in FY97.

Measuring and Modeling for OB/OD Permitting (SERDP CP-251): The U.S. armed forces are estimated to have 400,000 tons of stockpile needing demilitarization and the stockpile is increasing at 40,000 tons per year. OB/OD disposal is a commonly used method but generates air pollutants and requires a RCRA permit. The objective of this

project was to develop a mobile meteorological and air pollution dispersion model for predicting impacts from OB/OD emissions. Accurate characterization and modeling of OB/OD emissions was expected to improve the process of obtaining a RCRA permit to operate. Project was completed in FY97.

In Situ Characterization of Point-of-Discharge Fine Particulate Emissions (ESTCP CP-0420): FY04 new start.

Low-VOC Coatings for Medium-Caliber Ammunition (ESTCP PP-0120): This project intends to reduce or eliminate VOC releases from the process of painting 20-mm, 25-mm, and 30-mm projectile bodies. The Army, Air Force, Marine Corps, and Navy use a number of different ammunition types with various weapon systems. In applying high-VOC coatings to medium-caliber ammunition, significant amounts of VOCs must be treated and/or disposed to prevent release to the atmosphere. Identifying and validating a suitable alternative coating will save time and resources by reducing or even eliminating the need for such treatment and/or disposal while also reducing the number of requirements imposed by the regulatory sector. Project is ongoing.

Powder Coating for Small-Arms Bullet Tip Identification (ESTCP PP-9702): Currently, all small-caliber tracer and incendiary ammunition is produced at the Lake City Army Ammunition Plant (LCAAP) in Independence, Missouri. So that soldiers or marines can select the correct ammunition while in combat or training, the ammunition is made identifiable by applying low volatile organic compound (VOC) paint to the projectile tip. As a substitute for traditional paint application processes, this project investigated a powder coating technology. The use of hazardous solvents in the paint formulation would be eliminated, and the occupational health of workers would improve. However, implementation on the 7.62-mm cartridge line alone at LCAAP would not be economically justifiable due to the currently low throughput rate. The payback on the estimated $40,000 cost for the required facility modifications would be 4-5 years unless the technology was also implemented on other types of ammunition. Project is complete.

4.5 Noise Pollution

Training and Testing Range Noise Control (Army): The objective for this project is to avoid the loss of, and the ability to use, testing and training ranges because of excessive noise. Loss avoidance and range sustainability is expected to be achieved by complying with all noise regulations, ordinances, and laws. Technology being developed for compliance includes software models used to forecast and assess noise impacts, and the knowledge to design ranges to minimize noise. Also, the project will demonstrate minimization of noise impacts at installations by implementing noise management programs and methodology to better plan and schedule range operations. The project is expected to be completed in FY06.

Advanced Acoustic Models for Military Aircraft Noise Propagation and Impact Assessment (SERDP CP-1304): New generation aircraft do not have current noise models for assessing the impact of their use. This project's objective is to develop new

generation tools and models to better protect availability of airspace near installations and at test and training ranges (Figure 4-3). The project began in FY02 and is ongoing.

Figure 4-3. Joint Strike Fighter – New Generation of Aircraft

Controlling, Assessing, Managing, and Monitoring the Noise Impacts from Weapons, Helicopters, and Aircraft on Training Readiness (SERDP CP-523): Noise impacts from range activities are causing difficulties in keeping ranges operational. The effort produced a validated model that was built by combining existing and accepted models. The model predicts dose-response data that provides the means to mitigate noise. The model is ANSI approved and should contribute significantly to protecting the operational capability of testing/training noise-related activities. Project was completed in FY97.

Airborne Weapons Noise Prediction Model (SERDP CP-1397): Currently there is no capability to predict noise from airborne weapons. The DoD developed many different models for noise predictions for specific types of uses, such as BNOISE2 for predicting noise impacts from artillery and explosives on land based ranges. This project will result in a model for predicting the noise levels generated from firing weapons from the air. Project is ongoing and anticipated to be complete in FY07.

Prediction Model for Impulsive Noise Impacts on Structures (SERDP CP-1398): Existing guidelines used to predict blast noise damage are overly conservative for long-range propagation. This project will develop a model to give DoD range managers and planners an accurate and precise structural damage prediction model. The model will enhance range sustainability as impact areas can be relocated or modified to reduce sound levels reaching nearby structures. Project is ongoing and anticipated to be complete in FY07.

Assessing and Controlling Blast Noise Emission (ESTCP CP-0006): The project demonstrates two new blast noise models: BNOISE2 for artillery and explosive operations and SARNAM for SARs. The accuracy of the models will be determined by comparing measured noise levels in training scenarios with predicted model noise levels. The project began in FY02 and is ongoing.

4.6 Range Management Issues

4.6.1 Range Management

Land Capability/Characterization (Army): The objective of this project is to improve the existing Army Training and Testing Area Carrying Capacity (ATTACC) methodology. The improved ATTACC will allow users to better understand the carrying capacity of a suitable land area under specific training activities. Improved assessment of land carrying capacity will give range managers sustainable range use capability by providing information for avoiding overuse. All protocols for improved estimation of land carrying capacity and characterization are expected by FY05.

Non-Invasive Species Control for Army Installations and Operations (Army): This project will improve nonnative, invasive species management by assessing impacts from military operations and providing control techniques. Military operations will be assessed for their effects on species establishment and spreading. The assessment is expected to provide the information needed to develop a cost-effective invasive species prevention, management, and control. The project is ongoing.

Sustainable Army Live-Fire Range Design and Maintenance (Army): The primary goal of this project is to ensure the operational capability of live-fire training. A model will be developed for range planning, design, and maintenance activities. The model will incorporate explosive safety, risk to natural resources, compliance with environmental requirements, and range carrying capacity. The project has begun and is scheduled to finish by FY07 with a standardized program for range design and retrofit.

Environmental Information Management System (Navy): The project's overall objective is to develop a GIS-based decision, research, and administrative record tool. The Navy's Environmental Information Management System (EIMS) will improve information management, retrieval, and analysis for enhanced compliance with environmental requirements such as the ESA. The project is ongoing.

Development of an Adaptive Framework for Management of Military Operations in Arid and Semiarid Regions to Minimize Watershed and In-Stream Impacts from Nonpoint Source Pollution (SERDP CP-1340): The objective of this project is to increase understanding of the processes contributing to NPS pollution from DoD training activities in arid and semiarid regions. An impact assessment and decisions tool for improved management will also be developed. The project is ongoing.

Alternative Future Scenarios: Phase I Development of a Modeling System (SERDP CS-1258): Urban development on lands adjacent to DoD installations produces the most impact and increases usage limitations for the military. This project used an alternative future scenario modeling to predict impacts to bases from development including: noise, plants and animals, cultural resources, air emissions, water pollution, and base-specific issues. The one-year project was completed in FY02.

Diagnostic Tools and Reclamation Technologies for Mitigating Impacts of DoD/DOE Activities in Arid Areas (SERDP CS-1131): This project was designed to overcome current gaps in diagnostic capabilities needed to distinguish between various degrees of sustainable and nonsustainable impacts from military training/testing in the arid Mohave Desert ecosystem at Fort Irwin, CA. Also, new and cost-effective rehabilitation techniques for restoration of disturbed habitats were explored and evaluated. This large-scale pilot project was completed in FY02.

Emerging and Contemporary Technologies in Remote Sensing for Ecosystem Assessment and Change Detection on Military Reservations (SERDP CS-1098): Project objective was to use emerging remote sensing technologies to identify and monitor land impacts from range operations. The research was designed to link ecological concepts (e.g., carrying capacity) to training and testing ecosystem changes. The project was completed in FY02.

Identify Resistant Plant Characteristics and Develop Wear-Resistant Plant Cultivars for Use on Military Training Lands (SERDP CS-1103): The project intends to develop wear-resistant plants and conduct field studies to quantify the effects of soil compaction and plant injury/regrowth from military training activities. Plants and seeded plots are under evaluation at Yakima Training Center, WA, Fort Carson, CO, and Logan, UT. The project was completed in FY03.

Improved Units of Measure for Training and Testing Area Carrying Capacity Estimation (SERDP CS-1102): The project objective is to extend the ATTACC methodology to include multiple measures of land condition. Enhancements include evaluation and revision to existing models to improve ATTACC's applicability to military lands. Models include soil erosion models, the Ecological Dynamics Simulation (EDYS), and models already in ATTACC that account for seasonal variation, and time-varying factors. The project is ongoing as the Army continues to develop the ATTACC methodology.

Riparian Ecosystem Management at Military Installations: Determination of Impacts of Restoration and Enhancement Strategies (SERDP CS-1186): This project intends to (1) increase understanding of riparian functions and assess the impacts to riparian functions from upland military training activities and prescribed fires for forest management; and (2) evaluate revegetation and woody debris addition as riparian restoration strategies. Eight catchment areas encompassing upland and direct riparian disturbances at Fort Benning, GA are being studied. The project began in FY01 and is ongoing.

RSim – A Regional Simulation to Explore Impacts of Resource Use and Constraints (SERDP CS-1259): The objective of this effort is to develop a user-friendly regional simulation program that integrates environmental effects of on-base range uses with off-base development. The simulation program builds upon the LUCAS (Land Use Change Analysis System) model to enhance the abilities of military planners to understand the implications of external land-use change, resource use, and future development policy on the sustainability of military land and mission. Effects to be considered include changes

in air and water quality, noise conditions, and habitats for TES and game species. The spatially explicit simulation model is being developed for the Fort Benning, GA (http://www-benning.army.mil/EMD/index.htm) region, but is being structured so that the basic framework (http://www.esd.ornl.gov/programs/SERDP/RSim/framework.html) can be applied to other installations and their regions. The project began in FY02 and is ongoing.

SERDP Ecosystems Management Program (SERDP CS-1114): The SERDP Ecosystem Monitoring Program (SEMP) was established in 1998 to perform long-term ecological monitoring at a military base (Fort Benning, GA) with possible expansion to some other bases in the future. The program objectives are to select DoD-relevant ecosystem management initiatives; manage long-term ecological monitoring systems(s); and facilitate the integration of results and findings or research into DoD ecosystem management practices. The program is ongoing and has two major initiatives, "Ecological Indicators" and "Threshold of Disturbance" involving seven interrelated projects: (1) Determination of Indicators of Ecological Change, (2) Development of Ecological Indicators for Land Management, (3) Indicators of Ecological Change, (4) Disturbance of Soil Organic Matter and Nitrogen Dynamics: Implications for Soil and Water Quality, (5) Threshold of Disturbance: Land Management Effects on Vegetation and Nitrogen Dynamics, (6) Semp Research Integration, and (7) Ecosystem Knowledge Mapping Project. Go to http://www.cecer.army.mil/KD/SEMP for additional information on these seven projects and other info/reports. Project began in FY98 and is ongoing.

The Evolving Urban Community and Military Installations: A Dynamic Spatial Decision Support System for Sustainable Military Communities (SERDP CS-1257): The project's main objective is to identify and address knowledge gaps in basic understanding of the risks to military ranges associated with land use transformation. Once the knowledge gaps are filled the Spatial Decision Support System (SDSS) will be developed. It will quantify current and future impacts of urbanization towards range readiness and sustainability based on predictive modeling. The SDSS model will be applied to identify military installations most at-risk from rapid urbanization. The model is an expansion of the National Science Foundation's Land Use Evolution and Impact Assessment Model (LEAM). The military's version (mLEAM) will be used to graphically analyze simulations of land use scenarios that include dynamics occurring inside and outside and installation's fence line. The project began in FY02 and is ongoing.

Dynamic Modeling of Military Training Impacts and Archaeological Site Distributions in Evolving Landscapes (SERDP CS-1130): The project acknowledges the three dimensional (3-D) nature of buried cultural resources and the potential impacts to the resources from military activities. Study objectives were to show (1) the effectiveness of the 3-D computer simulation approach at assessing risk to subsurface archeological resources; and (2) the transferability of the model to predict risks to buried resources at other installations. Dynamic modeling of cultural resources was enabled by extending the existing Channel-Hillside Integrated Landscape Development (CHILD) model. Using known archeological records and historical military training activities at Fort Riley, KS with the CHILD model produced 3-D model that creates "archeological

sensitivity" maps. The maps provide a tool to identify the probability of locating buried resources and the degree the resources are at risk from military training activities. After comparing conventional 2-D maps to the 3-D "archeological sensitivity" maps of the same basin, deficiencies in the ability of 2-D maps to locate subsurface resources were revealed. The project was completed in FY00.

Digital Terrain Modeling and Distributed Soil Erosion Simulation/Measurement for Minimizing Environmental Impacts of Military Training (SERDP CS-752): Military training operations contribute to soil erosion and siltation of waterways. The objective was to develop and enhance three models to improve the ability to predict the spatial and temporal runoff, soil erosion, and siltation in a complex military watershed. The resulting erosion model is a refinement of the Universal Soil Loss Equation and is ready for incorporation into ATTACC. An upland erosion algorithm improved the two-dimensional (2-D), rainfall/runoff watershed model (CASC2D) and has been validated and incorporated into the Watershed Management System used by the Waterways Experimentation Center of the Army Corps of Engineers. A 2-D simulation water erosion model (SIMWE) was developed to predict erosion and sediment transport to complex terrain, soil, and cover conditions. SIIMWE was successfully used to analyze and design the placement of erosion protection measures based on land cover. The project was completed in FY98.

Initial Evaluation for Assessing Military Training and Testing Impacts on Natural and Cultural Resources (SERDP CS-1048): There are significant concerns regarding the environmental impacts to air, water, and land resources from DoD training and testing activities. Project CS-1048 objectives were to identify methodological approaches, procedures, data requirements, and existing data sources for the quantitative assessment of training impacts on natural and cultural resources. This one-year study resulted in a new, risk-based approach to natural and cultural resource management on military installations. The project was completed in FY96 and served as a foundation for SERDP project CS-1054.

Development and Demonstration of a Risk Assessment Framework for Natural Resources on Military Training and Testing Lands (SERDP CS-1054): The objective of this project was to develop a structured, scientifically valid ecological risk assessment (ERA) framework that may be used for the rapid, cost-effective evaluation of the potential effects of single, multiple, and cumulative training and testing impacts. An ERA framework was developed that provides the basis to link physical, chemical, and biological stressors to direct and indirect risks. The framework relates natural resource risk with risk to the mission. The project was finished in FY00.

Analysis and Assessment of Military and Nonmilitary Impacts on Biodiversity: Framework for Environmental Management on DoD Lands Using Mojave Desert as a Regional Case Study (SERDP CS-1055): The purpose of CS-1055 was to evaluate the effects of human stressors (military and nonmilitary) on biodiversity and related environmental concerns within the Mojave Desert ecoregion in the present and in 2020. The project approach is to develop a spatially-oriented database; organize stakeholders

and identify key environmental issues and human valuations; field data collection, population of database, and assembly of model; analysis of habitat relationships for key species; assessing management strategies for key species; and using modeling for evaluation of future land use scenarios on stressors, biodiversity, and other environmental issues. Field data was collected at the MCAGCC and adjacent Joshua Tree National Park. The project was completed in FY00 and accomplished its objectives.

Predicting the Effects of Ecosystem Fragmentation and Restoration: Management Models for Animal Populations (SERDP CS-1100): This project is developing species-specific models to predict the fragmentation of animal habitats caused by military training and testing. The model will predict the responses of mobile animal species to habitat fragmentation and restoration efforts. The project links three areas of investigation: (1) acquisition of animal field data on the responses of animals to their habitat fragmentation, (2) the mapping of animal habitats in three dimensions and at scales relative to habitat management, and (3) the linking of empirical ecological data and spatially explicit habitat information in a management-oriented model. Benefits of the project include the ability to compare the effects of alternative land use strategies on species-of-concern. Data for the project is being collected from Camp Navaho and Fort Huachuca/San Pedro, AZ and Mount Trumbull, WA. Project is ongoing.

Integrated Control and Assessment of Knapweed and Cheatgrass on DoD Installations (SERDP CS-1145): Heavy maneuvering of troops and equipment at military installations causes large disturbances where native vegetation is stressed, soil is loosened, and invasive noxious plants often take hold. The project objective is to develop a strategy for the control, monitoring, and prediction of knapweed and cheatgrass infestations on DoD installations in the western United States. Biological control, fire, manipulation of the soil nitrogen availability, seeding with native late-seral species, and restoration of the soil community are combined in this strategy. Results will be incorporated into an existing EDYS model. Results indicate combinations of treatments that seek to stress noxious weeds and simultaneously aid in the establishment of desirable species can be an effective strategy for managing nonnative weeds. Project is ongoing.

Application of ROV-Based Video Technology to Complement Coral Reef Resource Mapping and Monitoring (SERDP CS-1333): Recent declines in coral reefs worldwide are of great concern. DoD is legally mandated to monitor coral reefs and provide environmental documentation for conducting military operations in these areas. Because of the rapidly declining coral reef ecosystems, scientific tools are needed to better understand the factors responsible for ecosystem changes in a spatial and temporal manner. This project is developing a remotely operated vehicle (ROV) to improve monitoring. The ROV will increase the speed and repeatability for monitoring and mapping reef plots. The project began in FY03 and is ongoing.

Analysis of Biophysical, Optical, and Genetic Diversity of DoD Coral Reef Communities Using Advanced Fluorescence and Molecular Biology Techniques (SERDP CS-1334): Because of the decline in coral reef ecosystems worldwide and under DoD jurisdiction, there is an increasingly urgent need to better understand the dynamics

degrading coral reefs. Objectives of the project are to (1) develop advanced techniques for rapid, nondestructive assessment of coral reef community health with the capability to quantify and identify natural and anthropogenic stressors; (2) develop prototype fluorosensor technologies for use in permanent underwater monitoring stations and remotely operated vehicles (ROVs); and collect a library of baseline data on the physiological, biophysical, bio-optical, and genetic diversity of coral reef ecosystems. The project began in FY03 and is being performed at three geographically separate DoD coral reef ecosystems.

Exotic Annual Grasses in Western Rangelands: Predicting Resistance and Resilience of Native Ecosystem Invasion (SERDP CS-1144): The invasion of nonnative annual grasses in the western United States is having a profoundly negative impact to native ecosystems. The objectives of this project are: (1) to determine if the distribution of grasses can be predicted using soil chemistry data; (2) construct a model that predicts which soils are resistant or susceptible to invasions of exotic grasses for a large watershed; (3) investigate positive feedback loops (e.g., altered soil conditions) that may perpetuate invasive annual grass dominance; and (4) examine ways to favor native plant reinvasion by altering soil chemistry. Results of this effort will provide land managers with a better understanding of the causes of exotic grass invasion, the ability to forecast susceptible areas, and techniques to reestablish lost habitat. This is an ongoing project.

Implementation and Commercialization of New Germplasms for Use on Military Ranges (ESTCP CP-0401): Project is a FY04 new start.

Passive Reactive Berm (PRBerm) to Provide Low Maintenance Lead Containment at Active Small Arms (ESTCP CP-0406): Project is a FY04 new start.

4.6.2 Range Residue/Scrap

Characterization of Scrap Metals for Mass Detonating Energetic Materials (SERDP CP-1194): Ranges generate a variety of scrap metal and materials from normal operations. Some of the scrap contains energetic material that can cause a safety and environmental concern. The research performed here explored automated screening using an amplifying fluorescent polymer (AFP). The goal is to cost-effectively discriminate energetic-containing material from inert scrap prior to a treatment process. AFP technology could be used after treatment to verify that material is explosive free and ready for recycle, reuse, or disposal. The pilot project was completed in FY02.

Removal, Degradation, and Recovery of Energetic Residues from Range Scrap (SERDP CP-1196): The backlog of scrap from active and closed ranges needs to be removed and systems and programs need implementation to sustain the scrap removal process. This project uses a mild, base hydrolysis of energetics at ambient temperatures in a lime-water solution. Research objectives are (1) determine lime solution parameters that increase the speed of solid energetics dissolution and degradation; (2) determine lime parameters that provide the greatest yield of removed energetic constituents; (3) treat scrap material with a laboratory system and determine an optimal treatment formulation;

and (4) perform cost analysis of optimized system. The process removed energetic material from scrap munitions using either acetone or a SuperSolve™/limewater soak over one to two days. Project completed in FY01.

Transportable Detonation Chamber Validation E-12 (Army): The Donovan Blast Chamber (TC-20) will be tested for its ability to dispose of chemical warfare material (nonstockpile). The intent is to validate a system that supplements the need for on-site destruction of munitions. Project is ongoing.

4.6.3 Risk Assessment

Hazard/Risk Assessment of Military Unique Compounds (Army): The project is directed toward the development of the ARAMS, which assists in the development of human and ecological risk assessment for exposure to explosives. The current system (ARAMS version 1.0) was released in FY02. The project intends to upgrade ARAMS to include data necessary for the risk assessment of propellants, smokes, and illuminants. The model includes process descriptors for fate and transport, aquatic and terrestrial uptake, human bioavailability data, and a toxicology database. Project is ongoing.

Toxicity and Degradation of Picric Acid and 2-6 DNT in Marine Sediments (Navy): Picric acid and 2-6 DNT degrade in marine sediments through UV radiation exposure and microbial degradation. This project assessed the toxicity and degradability of the two MCs in silt/clay and sandy sediments. Project is complete.

Development of Marine Sediment Toxicity Data form Ordnance Compounds (Navy): Ecotoxicity data for energetic material is incomplete. A toxicity identification evaluation (TIE) was conducted in the marine sediments at Jackson Park Housing Complex, WA. Munition constituents were found to not possess an unacceptable risk to the environment. Instead, toxicity of sediments were found to be caused by additional site contaminants including polycylic aromatic hydrocarbons (PAH)s and naturally generated ammonia. Project is completed.

Development of Ecological Toxicity and Biomagnification Data for Explosives Contaminants in Soil (SERDP CU-1221): Explosives contamination in soil can be toxic to ecological receptors. The research will determine the toxicity and bioaccumulation potential of RDX, HMX, 2,4-DNT, 2,6-DNT, and TNB in selected soil invertebrates and plants. The work will produce soil screening values used to screen potentially contaminated sites early in the risk assessment. Screening of sites early in the cleanup process negates the need for a expensive and time consuming full-scale ecorisk assessments and will result in significant cost savings. This is an ongoing project that began in FY01.

Toxicological Impact of Ammonium Perchlorate on Fish (SERDP CU-1222): Perchlorate can impact the reproduction, thyroid function, and general health of fish. The study will determine the toxicological impacts and bioconcentration in fish from perchlorate exposure. Laboratory and field studies are being conducted at Lake Mead, NV. This is an ongoing project that began in FY01.

Ecological Risk Assessment of Ammonium Perchlorate in Fish, Amphibians, and Small Mammals (SERDP CU-1223): The knowledge of ecological risks to ecological receptors needed expansion. Using laboratory and field studies the project examined the impacts from perchlorate exposure on fish, amphibians, and mammals at the Longhorn Army Ammunition Plant. The project determined the ramifications of perchlorate exposure to earthworms, fish, and raccoons. Environmental transport and food chain models were developed for contaminated sites. The project was complete in FY00.

Ecological Risk Assessment of Perchlorate and Explosives in Avian Species, Rodents, Amphibians, and Fish: (SERDP CU-1235): This project's focus is to expand the ecorisk knowledge base from SERDP CU-1223 for perchlorate and explosives. Bioavailability across trophic levels was evaluated and toxicological impacts of perchlorate, explosives, and their metabolites on exposed biota were assessed. It is unclear what explosives and metabolites were evaluated. The project is ongoing and began in FY01.

The Effects of Ammonium Perchlorate on Reproduction and Development of Amphibians (SERDP CU-1236): This project examines the long-term effects of perchlorate on developing amphibian growth, metamorphosis, general health, and reproductive capacity of adult females. The project will determine UV sensitivity affects, bioaccumulation from plants (food source), and iodine-amended water effects to perchlorate exposed amphibians. Project is ongoing and began in FY02.

Validation of a Rapid and Low-Cost Method for Prediction of the Oral Bioavailability of Lead from Small Arms Range Soils (ESTCP CU-0222): This demonstration is to validate a cost-effective, rapid method to estimate oral bioavailability of lead. The bioavailability of lead is a term used to model the risk from SARs. The project began in FY02 and is ongoing.

The Effects of Perchlorate on Developing and Adult Birds (SERDP CU-1242): This research intends to establish safe perchlorate exposure levels for embryos, chicks, and adults based on its effect on thyroid function, growth, and development (Figure 4-4).

Figure 4-4. Bobwhite Quail is One Species to Be Tested

Also, the effort will attempt to develop assessment endpoints through the evaluation of thyroid function measurements. This is an ongoing project that began in FY02.

4.6.4 Undersea Cables. There are no known RDT&E projects in this area.

4.6.5 Pollution Prevention. The number of emerging pollution prevention technologies is much larger than can be represented in this section. The complete list of the technologies is shown later in this section in Table 4-1. Prevention of pollution is the ideal method for sustaining any industrial process including operational DoD testing and training ranges. However, the focus of this report is to address immediate range sustainability issues first and foremost to keep the ranges open. Below is a synopsis of several DoD projects furthering the pollution prevention programs at Navy ranges.

The technologies are organized into (1) minimization and prevention of pollution generated during manufacturing of munitions and energetic materials (ESTCP PP-9804); (2) replacing munitions components that generate and release contaminants into the environment (SERDP PP-1307) (3) developing methods to reuse and recycle energetic material that would typically be wasted (SERDP PP-660); (4) elimination or reduction of toxic chemicals in ordnances and substitution with more benign compounds (SERDP PP-1308); and (5) completely replacing a munition with an environmentally acceptable alternative (SERDP PP-1237).

Environmentally Acceptable Medium-Caliber Ammunition Percussion Primers (SERDP PP-1308): The goal of this project is to substitute the toxic components (e.g., antimony sulfide) currently used in medium-caliber percussion primer with environmentally benign material. The project was begun in FY02 and is ongoing.

Green Medium-Caliber Munitions (SERDP PP-1237): This is a long-term project aimed at resolving medium-caliber ammunition environmental problems. The highest priority is replacement of lead and toxic heavy metals. The project team is focusing on nine munitions component areas including ignition systems, miniature detonators, miniature fuse electronics, propellants, tracers/incendiaries, detonators, paints, sealants/adhesives, and metal parts. The project technical advisory committee will be developing SERDP SONs in the nine medium-caliber ammunition focus areas through FY08. The project began in FY01.

Investigation of Alternative Energetic Compositions for Small Electro-Explosive Devices for Medium-Caliber Ammunition (SERDP PP-1307): The goal of this project is to evaluate and test alternative chemicals to replace heavy metals in detonators for medium-caliber rounds. The alternative is 1,1-diamino-3,3,5,7,7-hexaazidocyclothetraphosphazene (DAHA), a material recently synthesized as a new primary explosive for medium-caliber ammunition. Tests on DAHA showed practical application in small arms, but were untested in medium-caliber munitions. The project is complete.

Extraction and Recycling of LOVA Propellants Using Supercritical Fluid Extraction (SERDP PP-660): Solid gun propellants and explosives are currently destroyed by the increasingly regulated OB/OD process. This project explored the conditions necessary for propellant recovery and recycling with two supercritical fluids and various

processing conditions. The project team extracted RDX from the LOVA propellant. They later began recovery of RDX and other energetic compounds from explosive munitions such as CompB (RDX/TNT/Wax). The project was completed in FY98.

Ordnance Manufacture, Maintenance, Use, and Surveillance to Enable Sustainable Ranges (Army): Smokes, obscurants, ordnance, and weapons systems release PEP. PEP has hazardous components that pose environmental and safety concerns. The objective of this five-year effort is to develop environmentally friendly explosives and propellant formulations. The project concludes in FY07 with the demonstration of alternatives to hydrazine fuels.

Lead-Free Projectiles for .22-Caliber Ammunition (ESTCP PP-0203): The objective of this project is to demonstrate a lead-free .22-caliber projectile that meets ammunition specification. The objective will be met by soliciting commercial sources. Projectiles from commercial sources will be evaluated against the specifications. The project began in FY02 and is ongoing.

Smoke and Dye Replacement (ESTCP PP-0122): The goal of this project is to provide the DoD with environmentally benign signal devices (e.g., colored smoke grenades) for military training and operations. The replacement devices will be required to pass several validation tests, human health assessments, and toxicological testing. If all tests and validations are successful, a Material Change Approval will be issued and the alternative smokes and dyes will go into production and military use. The project began in FY02 and is ongoing.

Nitrocellulose-Based Propellant Manufacturing Waste Minimization (ESTCP PP-9804): All branches of DoD use a nitrocellulose-based propellant in their 2.75-inch rocket systems. However, the process generates significant waste materials such as nitroglycerine and water. The technology being demonstrated will reduce propellant scrap, nitroglycerine emissions, and improve worker safety due to automation. The project is ongoing.

4.7 Summary of Emerging Range Sustainability Projects

Table 4-1 summarizes range sustainability projects completed and ongoing up to FY04. Not included are land- or water-based UXO detection technologies. Projects are grouped into their most relevant category of range sustainability. Each project's primary sponsor is identified along with the project title.

Table 4-1. Range Sustainability Project Summary

Category	Project Name	Sponsor	Date Completed/Due
Threatened and Endangered Species	Baseline TES Inventories and Research	ARMY	Ongoing, FY07 completion
	Reducing Impacts of TES on Military Readiness	ARMY	Ongoing, FY08 completion
	Acoustic Monitoring of Threatened and Endangered Species in Inaccessible Areas (CS-1185)	SERDP	Ongoing, begun FY02
	Impacts of Military Training and Land Management on Threatened and Endangered Species in the Southeastern Fall Line/Sandhills Community (CS-1302)	SERDP	Ongoing, begun FY02
	The Effects of Aircraft Overflights on Birds of Prey (CS-89)	SERDP	Completed FY97
	Ecological Biomarkers: Monitoring Wildlife Fauna at DoD Installations (CS-244)	SERDP	Completed FY97
	Threatened, Endangered, and Sensitive Resources (CS-507)	SERDP	Completed FY99
	Assessment of Training Noise Impacts on the Red-Cockaded Woodpecker (CS-1083)	SERDP	Completed FY01
	Methods for Assessing the Impact of Fog Oil on Availability, Palatability, and Food Quality of Relevant Life Stages of Insect Food Sources for Threatened and Endangered Species (CS 1262)	SERDP	Ongoing, begun FY02
	Toxicological Effects of Smokes and Obscurants on Aquatic Threatened and Endangered Species (CS-1332)	SERDP	Ongoing, begun FY03
Munitions Constituents (Operational Ranges) – *Characterization and Monitoring*	Encapco/Depleted Uranium	NAVY	Ongoing
	Trace Analysis of Perchlorate in Environmental Samples	NAVY	Ongoing
	Field Portable X-ray Fluorescence (FP-XRF) Determination of Metals in Post-Blast Ordnance Residues	ARMY	Completed
	Sampling for Explosives Residues at Fort Greely, Alaska Reconnaissance Visit July 2000	ARMY	Completed
	Estimates for Explosives Residue from the Detonation of Army Munitions	ARMY	Completed
	On-Site Processing and Subsampling of Surface Soil Samples for the Analysis of Explosives	ARMY	Completed
	Study of Five Discrete Interval-Type Groundwater Sampling Devices	ARMY	Completed
	Guide for Characterization of Sites Contaminated with Energetic Material	ARMY	Completed
	Field Gas Chromatography/Thermionic Detector System for On-Site Determination of Explosives in Soils	ARMY	Completed
	Development of a Field Method for Quantifying Ammonium Picrate and Picric Acid in Soil and Water	ARMY	Completed
	Underwater Ordnance Casing Corrosion Research	NAVY	Ongoing
	Integrated Automated Analyzer for Monitoring of Explosives in Groundwater (CU-1297)	SERDP	Completed FY02
	Novel Technology for Wide-Area Screening of ERC-Contaminated Soils (CU-1228)	SERDP	Completed FY02
	A Predictive Capability for the Source of Terms of Residual Energetic Materials from Burning and/or Detonating Activities (CP-1159)	SERDP	Ongoing, begun FY02
	Distribution and Fate of Energetics on DoD Test and Training Ranges (CP-1155)	SERDP	Ongoing

Table 4-1. Range Sustainability Project Summary (page 2 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Munitions Constituents (Operational Ranges) – *Characterization and Monitoring (cont'd)*	Enhanced Electromagnetic Tagging for Embedded Tracking of Munitions and Ordnance During Future Remediation Efforts (PP-1272)	SERDP	Ongoing, begun FY02
	Rapid Detection of Explosives and Other Pollutants (CU-28)	SERDP	Completed FY97
	Detection and Measurement of Explosives in Groundwater Using In Situ Electrochemical Sensors (CU-1220)	SERDP	Completed FY01
	Long-Term Monitoring for Explosives-Contaminated Groundwater (CU-1298)	SERDP	Completed FY02
	Portable SER Instrument for Explosives Monitoring (CU-9917)	ESTCP	Ongoing
	Explosives Detecting Immunosensors (CU-9713)	ESTCP	Completed
	Applied Innovative Technologies for Characterization of Explosives-Contaminated DoD Building Foundations and Underlying Soils (CU-0130)	ESTCP	Completed
	Naval Shoreside Ordnance Environmental Survey	Navy	Completed
Munitions Constituents (Operational Ranges) – *Fate and Transport*	Land Rehabilitation	ARMY	Ongoing
	Stability of CL-20, TNAZ, HMX, RDX, NG and PETN in Moist, Unsaturated Soils	ARMY	Completed
	Environmental Fate and Transport of a New Energetic Material, CL-20 (CP-1254)	SERDP	Ongoing, began FY02
	Factors Affecting the Fate and Transport of CL-20 in the Vadose Zone and Groundwater (CP-1255)	SERDP	Ongoing, began FY02
	Environmental Fate and Transport of a New Energetic Material, CL-20 (CP-1256)	SERDP	Ongoing, began FY02
	Measurement and Modeling of Energetic Material Mass Transfer to Pore Water (CP-1227)	SERDP	Ongoing, begun FY01
	Impacts of Fire Ecology Range Management (FERM) on the Fate and Transport of Energetic Materials on Testing and Training Ranges (CP-1305)	SERDP	Ongoing, began FY02
	Assessing the Impact of Maneuver Training on NPS Pollution and Water Quality (CP-1339)	SERDP	Ongoing
Munitions Constituents (Operational Ranges) – *Mitigation Measures*	Electrokinetic Remediation of Contaminated Soils	ARMY	Ongoing, completion FY04
	Enhanced Alternatives and In Situ Treatment Technologies for Explosives, Organics, and Solvents in Groundwater	ARMY	Ongoing
	Innovative and In Situ Treatment Technologies for Soils Contaminated with Inorganics	ARMY	Ongoing, begun FY02
	Treatment Techniques for Wastewaters from Munitions Production	ARMY	Ongoing, FY04 completion
	Use of Military Demolition Explosives in a Remediation Project	ARMY	Completed
	Encapco/Depleted Uranium	NAVY	Ongoing
	Electrochemical Oxidation of Energetic Waste	NAVY	Completed
	Molten Salt Oxidation (MSO) Technology	NAVY	Completed
	Continuous Treatment of Low Levels of TNT and RDX in Range Soils Using Surface Liming	ARMY	Completed
	Engineering Transgenic Plants for the Sustained Containment and In Situ Treatment of Energetic Materials (CU-1318)	SERDP	Ongoing, begun FY02
	Fe(0)-Based Bioremediation of RDX-Contaminated Groundwater (CU-1231)	SERDP	Ongoing, begun FY02

Table 4-1. Range Sustainability Project Summary (page 3 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Munitions Constituents (Operational Ranges) – *Mitigation Measures (continued)*	Genetic and Biochemical Basis for the Transformation of Energetic Materials (RDX, TNT, DNTs) by Plants (CU-1319)	SERDP	Ongoing, begun in FY02
	Identification of Metabolic Routes and Catabolic Enzymes Involved in Phytoremediation of the Nitro-Substituted Explosives TNT, RDX, and HMX (CU-1317)	SERDP	Ongoing, begun in FY02
	Immobilization of Energetics on Live-Fire Ranges (CU-1229)	SERDP	Ongoing, begun FY02
	In Situ Bioreduction and Removal of Ammonium Perchlorate (CU-1162)	SERDP	Ongoing, begun in FY00
	In Situ Bioremediation of Perchlorate (CU-1163)	SERDP	Completed FY01
	In Situ Bioremediation of Perchlorate-Impacted Groundwater (CU-1164)	SERDP	Completed FY01
	Bioremediation of Hydrazine (CU-118)	SERDP	Completed FY97
	Explosives Conjugation Products in Remediation Matrices (CU-715)	SERDP	Completed FY98
	Federal Integrated Biotreatment Research Consortium (FIBRC): Flask to Field Initiative (CU-720)	SERDP	Completed FY01
	Natural Attenuation of Explosives in Soil and Water Systems at DoD Sites (CU-1043)	SERDP	Completed FY98
	Fe(0)-Based-Bioremediation of RDX-Contaminated Groundwater with Sequential Reactive Treatment Zones (CU-1176)	SERDP	Completed FY00
	Topical Lime Treatment for Containment of Source Zone Energetics Contamination (CU-1230)	SERDP	Completed FY01
	Development and Application of a Flash Pyrolysis-GC/MS Assay for Documenting Natural and Engineered Attenuation of Nitroaromatic Compounds (CU-1233)	SERDP	Completed FY02
	Sequential Electrolytic Degradation of Energetic Compounds in Groundwater (CU-1234)	SERDP	Ongoing, begun FY01
	Novel Pathways of Nitroaromatic Metabolism: Hydroxylamine Formation, Reactivity, and Potential for Ring Fission for Destruction of TNT (CU-1214)	SERDP	Ongoing, begun FY02
	Remediation of Explosives-Contaminated Groundwater with Zero-Valent Iron (CU-1232)	SERDP	Completed FY02
	Enhancement of In Situ Bioremediation of Energetic Compounds by Coupled Abiotic/Biotic Processes (CU-1376)	SERDP	Ongoing, begun FY04
	Biodegradation of Nitroaromatic Compounds by Stimulating Humic Substances – and Fe (III)-Reduction (CU-1377)	SERDP	Ongoing, begun FY04
	Groundwater Chemistry and Microbial Ecology Effects on Explosives Biodegradation (CU-1378)	SERDP	Ongoing, begun FY04
	On-Range Treatment of Ordnance Debris and Bulk Energetics Resulting from Low-Order Detonations (CP-1330)	SERDP	Ongoing, begun FY02
	Demonstration of Anaerobic Percolating Biofilters for Treating Perchlorate in Wastewater Generated During Rocket Motor Testing (CP-0403)	ESTCP	Ongoing, begun FY04
	Biologically Active Zone Enhancement (BAZE) for In Situ RDX Degradation in Groundwater (CU-0110)	ESTCP	Ongoing, begun FY02
	Comparative Demonstration of Active, Semipassive, and Passive In Situ Bioremediation Approaches for Perchlorate-Impacted Groundwater (CU-0219)	ESTCP	Ongoing, begun FY02

Table 4-1. Range Sustainability Project Summary (page 4 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Munitions Constituents (Operational Ranges) – *Mitigation Measures (continued)*	In Situ Bioremediation of Perchlorate in Groundwater (CU-0224)	ESTCP	Ongoing, begun FY02
	Edible Oil Barriers for Treatment of Chlorinated Solvent- and Perchlorate-Contaminated Groundwater (CU-0221)	ESTCP	Ongoing
	Perchlorate Removal, Destruction, and Field Monitoring Demonstration (CU-0312)	ESTCP	Ongoing
	Permeable Mulch Biowall for Enhanced Bioremediation of Perchlorate in Groundwater at a DoD Facility (CU-0427)	ESTCP	Ongoing, begun FY04
	Evaluation of Potential for Monitored Natural Attenuation of Perchlorate in Groundwater (CU-0428)	ESTCP	Ongoing, begun FY04
	Field Comparison of Biofouling Control Measures for In Situ Bioremediation of Groundwater (CU-0429)	ESTCP	Ongoing, begun FY04
	In Situ Bioremediation of Perchlorate in Vadose Zone Source Areas (CU-0435)	ESTCP	Ongoing, begun FY04
	Bacterial Degradation of DNT and TNT Mixtures (CU-1212)	SERDP	Ongoing
	Remediation of TNT and RDX in Groundwater Using Zero-Valent Iron Permeable Reactive Barriers (CU-0223)	ESTCP	Ongoing, begun FY02
	In Situ Bioremediation of Energetic Compounds in Groundwater (CU-0425)	ESTCP	Ongoing, begun FY04
	Treatment of RDX and HMX Plumes Using Mulch Biowalls (CU-0426)	ESTCP	Ongoing, begun FY04
	Peroxone Treatment of Explosives-Contaminated Groundwater (CU-9514)	ESTCP	Completed
	Monitored Natural Attenuation of Explosives in Groundwater (CU-9518)	ESTCP	Completed
	Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands (CU-9520)	ESTCP	Completed
	Joint Small Arms Range Remediation (CU-9513)	ESTCP	Completed
	Grenade Range Management Using Lime for Dual Role of Metals Immobilization and Explosives Transformation (CP-0216)	ESTCP	Ongoing
	Microbial Degradation of RDX and HMX (CU-1213)	SERDP	Ongoing
Munitions Constituents (Operational Ranges) – *OB/OD-Related Issues*	Evaluation of the Use of Waste Energetics as Supplemental Fuels (CP-524)	SERDP	Completed FY97
	Enzymes for Degradation of Energetic Materials and Demilitarization of Explosives Stockpiles (CP-1078)	SERDP	Completed FY99
	Safe Deactivation of Energetic Materials and Use of Byproduct as Epoxy Curing Agents (CP-1079)	SERDP	Completed FY00
	Recovery and Reuse of HMX/RDX from Propellants and Explosives (CP-9708)	ESTCP	Completed FY00
	Confined Burn Facility Open Burning Replacement Project	NAVY	Ongoing

Table 4-1. Range Sustainability Project Summary (page 5 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Protected Marine Resources	Determining Source Levels, Sound Fields, and Body Sizes of Singing Humpback Whales in the Hawaiian Wintering Grounds	NAVY	Ongoing, begun FY02
	Development and Field Testing of the DTAG for Deep-Diving *Odontocetes*	NAVY	Ongoing, begun FY02
	Effects of Sound on the Marine Environment (ESME) and Environmental Consequences of Underwater Sound (ECOUS)	NAVY	Ongoing
	Marine Mammal Comp liance Tools	NAVY	Ongoing
	Marine Mammal Monitoring Capabilities for the PMRF Instrumented Test Range	NAVY	Ongoing
	Marine Mammal Monitoring on Navy Undersea Ranges	NAVY	Ongoing
	Miniature Acoustic Recording Tag to Assess Marine Wildlife Response to Sound	NAVY	Ongoing
	Pinniped Bioacoustics: Auditory Mechanisms, Temporary Threshold Shift, and Effects of Noise on Signal Reception	NAVY	Ongoing
	Prediction of Acoustic Safety Criteria for Marine Mammals	NAVY	Ongoing
	Automated 3D Tracking of Sperm Whales Using Towed Arrays	NAVY	Ongoing
	Acoustical and Visual Monitoring for Marine Mammals at the Navy's Southern California Offshore Range (CS-1189)	SERDP	Ongoing, begun FY02
	Acoustic Response and Detection of Marine Mammals Using an Advanced Digital Recording Tag (CS-1188)	SERDP	Ongoing, begun FY01
	Information Technology Tools for Assessment and Prediction of the Potential Effects of Military Noise on Marine Mammals (CS-1082)	SERDP	Completed FY00
	Whale Monitoring Using Navy IUSS (CS-48)	SERDP	Completed FY98
	Marine Mammal Responses to Low Frequency Sound (CS-1069)	SERDP	Completed FY98
	Predictive Spatial Analysis of Marine Mammal Habitats (CS-1390)	SERDP	Ongoing, begun FY04
	Predictive Modeling of Marine Mammal Density from Existing Survey Data and Model Validation Using Upcoming Surveys (CS-1391)	SERDP	Ongoing, begun FY04

Table 4-1. Range Sustainability Project Summary (page 6 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Air Pollution	Particulate Matter/Dust Control	ARMY	Ongoing, FY06 completion
	Contained Combustion Technology for Propellants and Propulsion Systems	NAVY	Completed FY02
	Rocket Motor Exhaust Scrubber for Static Firing Operations	NAVY	Ongoing
	A Field Program to Identify Toxic Release Inventory (TRI) Chemicals and Determine Emission Factors from DoD Munitions Activities (CP-1197)	SERDP	Ongoing, begun FY01
	Adaptive Grid Modeling and Direct Sensitivity Analysis for Predicting the Air Quality Impacts of DoD Activities (CP-1249)	SERDP	Completed FY02
	Characterization of $PM_{2.5}$ Dust Emissions from Training/Testing Range Operations (CP-1190)	SERDP	Ongoing, begun FY01
	Fundamental Studies of Air Emissions from DoD Munitions and Novel Approaches for Their Detection (CP-1193)	SERDP	Completed FY01
	Development of a GIS-Based Complex Terrain Model for Atmospheric Dust Dispersion (CP-1195)	SERDP	Ongoing, begun FY01
	Particulate Matter Emissions Factors for Dust from Unique Military Activities (CP-1399)	SERDP	Ongoing, begun FY04
	Development of Emissions Factors for Particulate Matter, Nitrogen Oxides, and Air Toxic Compounds from Military Aircraft (CP-1402)	SERDP	Ongoing, begun FY04
	Characterization of Open Burning/Open Detonation Emissions (CP-247)	SERDP	Completed FY97
	Measuring and Modeling for OB/OD Permitting (CP-251)	SERDP	Completed FY97
	In Situ Characterization of Point-of-Discharge Fine Particulate Emissions (CP-0420)	ESTCP	Ongoing, begun FY04
	Low-VOC Coatings for Medium-Caliber Ammunition (PP-0120)	ESTCP	Ongoing
	Powder Coating for Small-Arms Bullet Tip Identification (PP-9702)	ESTCP	Completed
Noise Pollution	Training and Testing Range Noise Control	ARMY	Ongoing, completion FY06
	Advanced Acoustic Models for Military Aircraft Noise Propagation and Impact Assessment (CP-1304)	SERDP	Ongoing, begun FY02
	Controlling, Assessing, Managing, and Monitoring the Noise Impact from Weapons, Helicopters, and Aircraft on Training and Readiness (CP-523)	SERDP	Completed FY97
	Airborne Weapons Noise Prediction Model (CP-1397)	SERDP	Ongoing, begun FY04
	Prediction Model for Impulsive Noise Impacts on Structures (CP-1398)	SERDP	Ongoing, begun FY04
	Assessing and Controlling Blast Noise Emission (CP-0006)	ESTCP	Ongoing, begun FY02

Table 4-1. Range Sustainability Project Summary (page 7 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Range Management Issues– *Range Management*	Land Capability/Characterization	ARMY	Ongoing, completion FY05
	Non-Invasive Species Control for Army Installations and Operations	ARMY	Ongoing
	Sustainable Army Live-Fire Range Design and Maintenance	ARMY	Ongoing, completion FY07
	Environmental Information Management System	NAVY	Ongoing
	Development of an Adaptive Framework for Management of Military Operations in Arid and Semiarid Regions to Minimize Watershed and In-Stream Impacts from Nonpoint Source Pollution (CP-1340)	SERDP	Ongoing
	Alternative Future Scenarios: Phase I Development of a Modeling System (CS-1258)	SERDP	Completed FY02
	Diagnostic Tools and Reclamation Technologies for Mitigating Impacts of DoD/DOE Activities in Arid Areas (CS-1131)	SERDP	Completed FY02
	Emerging and Contemporary Technologies in Remote Sensing for Ecosystem Assessment and Change Detection on Military Reservations (CS-1098)	SERDP	Completed FY02
	Identify Resilient Plant Characteristics and Develop Wear Resistant Plant Cultivars for Use on Military Training Lands (CS-1103)	SERDP	Completed FY03
	Improved Units of Measure for Training and Testing Area Carrying Capacity Estimation (CS-1102)	SERDP	Ongoing
	Riparian Ecosystem Management at Military Installations: Determination of Impacts of Restoration and Enhancement Strategies (CS-1186)	SERDP	Ongoing, begun FY01
	RSim – A Regional Simulation to Explore Impacts of Resource Use and Constraints (CS-1259)	SERDP	Ongoing, begun FY02
	SERDP Ecosystems Management Program (CS-1114)	SERDP	Ongoing, begun FY98

Table 4-1. Range Sustainability Project Summary (page 8 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Range Management Issues – *Range Management (cont'd)*	The Evolving Urban Community and Military Installations: A Dynamic Spatial Decision Support System for Sustainable Military Communities (CS-1257)	SERDP	Ongoing, begun FY02
	Dynamic Modeling of Military Training Impacts and Archeological Site Distributions in Evolving Landscapes (CS-1130)	SERDP	Completed FY00
	Digital Terrain Modeling and Distributed Soil Erosion Simulation/Measurement for Minimizing Environmental Impacts of Military Training (CS-752)	SERDP	Completed FY98
	Initial Evaluation for Assessing Military Training and Testing Impacts on Natural and Cultural Resources (CS-1048)	SERDP	Completed FY96
	Development and Demonstration of a Risk Assessment Framework for Natural Resources on Military Training and Testing Lands (CS-1054)	SERDP	Completed FY00
	Analysis and Assessment of Military and Nonmilitary Impacts on Biodiversity: Framework for Environmental Management on DoD Lands Using Mojave Desert as a Regional Case Study (CS-1055)	SERDP	Completed FY00
	Predicting the Effects of Ecosystem Fragmentation and Restoration: Management Models for Animal Populations (CS-1100)	SERDP	Ongoing
	Integrated Control and Assessment of Knapweed and Cheatgrass on DoD Installations (CS-1145)	SERDP	Ongoing
	Application of ROV-Based Video Technology to Complement Coral Reef Resource Mapping and Monitoring (CS-1133)	SERDP	Ongoing, begun FY03
	Analysis of Biophysical, Optical and Genetic Diversity of DoD Coral Reef Communities Using Advanced Fluorescence and Molecular Biology Techniques (CS-1134)	SERDP	Ongoing, begun FY03
	Exotic Annual Grasses in Western Rangelands: Predicting Resistance and Resilience of Native Ecosystem Invasion (CS-1144)	SERDP	Ongoing
	Implementation and Commercialization of New Germplasms for Use on Military Ranges (CP-0401)	ESTCP	Ongoing, begun FY04
	Passive Reactive Berm (PRBerm) to Provide Low Maintenance Lead Containment at Active Small Arms (CP-0406)	ESTCP	Ongoing, begun FY04
Range Management Issues – *Range Residue/Scrap*	Characterization of Scrap Metals for Mass Detonating Energetic Materials (CP-1194)	SERDP	Completed FY02
	Removal, Degradation and Recovery of Energetic Residues from Range Scrap (CP-1196)	SERDP	Completed FY01
	Transportable Detonation Chamber Validation E-12	ARMY	Ongoing

Table 4-1. Range Sustainability Project Summary (page 9 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Range Management Issues – *Risk Assessment*	Hazard/Risk Assessment of Military Unique Compounds	ARMY	Ongoing, begun FY02
	Toxicity and Degradation of Picric Acid and 2-6 DNT in Marine Sediments	NAVY	Completed
	Development of Marine Sediment Data for Ordnance Compounds	NAVY	Completed
	Development of Ecological Toxicity and Biomagnification Data for Explosives-Contaminated Soils (CU-1221)	SERDP	Ongoing, begun FY01
	Toxicological Impact of Ammonium Perchlorate on Fish (CU-1222)	SERDP	Ongoing, begun FY01
	Ecological Risk Assessment of Ammonium Perchlorate on Fish, Amphibians, and Small Mammals (CU-1223)	SERDP	Completed FY00
	Ecological Risk Assessment of Perchlorate in Avian Species, Rodents, Amphibians and Fish (CU-1235)	SERDP	Ongoing, begun FY01
	The Effects of Ammonium Perchlorate on Reproduction and Development of Amphibians (CU-1236)	SERDP	Ongoing, begun FY02
	Validation of a Rapid and Low-Cost Method for Prediction of the Oral Bioavailability of Lead from Small Arms Range Soils (CU-0222)	ESTCP	Ongoing, begun FY02
	The Effects of Perchlorate on Developing and Adult Birds (CU-1242)	SERDP	Ongoing, begun FY02
Range Management Issues – *Pollution Prevention*	DoD/DOE Clean Agile Manufacturing of Energetics (PP-63)	SERDP	Completed FY98
	Extraction and Recycling of LOVA Propellants Using Supercritical Fluid Extraction (PP-660)	SERDP	Completed FY98
	Laser Ignition to Replace Chemical Ordnance Igniters for Propulsion (PP-680)	SERDP	Completed FY98
	Recycling Propellants in Nonpolluting Supercritical Fluids: Novel Computational Chemistry Models for Predicting Effective Solvents (PP-695)	SERDP	Completed FY98
	Solventless Pyrotechnic Manufacturing (PP-757)	SERDP	Completed FY98
	Solventless Manufacture of Artillery Propellant Using Thermosplastic Elastomer Binder (PP-867)	SERDP	Completed FY99
	Elimination of Toxic and VOC Constituents from Small-Caliber Ammunition (PP-1057)	SERDP	Completed FY00
	Elimination of Toxic Materials and Solvents from Solid Propellant Components (PP-1058)	SERDP	Completed FY00
	Life Cycle Costing/Energetics Production (PP-1068)	SERDP	Completed FY96
	Insensitive Munitions (PP-1072)	SERDP	Completed FY99
	Green Energetic Materials (PP-1115)	SERDP	Completed FY98
	Castable, Solvent-Free Red Phosphorus Smokes for Target Markers (PP-1180)	SERDP	Completed FY02
	Investigation of MIC Materials for Electrically Initiated Lead Free Primers (PP-1183)	SERDP	Completed FY01
	Environmentally Acceptable Medium-Caliber Ammunition Percussion Primers (PP-1308)	SERDP	Ongoing, begun FY02

Table 4-1. Range Sustainability Project Summary (page 10 of 10)

Category	Project Name	Sponsor	Date Completed/Due
Range Management Issues – *Pollution Prevention (cont'd)*	Green Medium-Caliber Munitions (PP-1237)	SERDP	Ongoing, completion FY08
	Twin Screw Extruder Production of MTTP Decoy Flares (PP-1240)	SERDP	Ongoing
	Enhanced Electromagnetic Tagging for Embedded Tracking of Munitions and Ordnance During Future Remediation Efforts (PP-1272)	SERDP	Ongoing
	Multispectral Munitions Locating System (PP-1273)	SERDP	Ongoing
	Safe and Environmentally Acceptable Sol-Gel-Derived Pyrophoric Pyrotechnics (PP-1276)	SERDP	Ongoing
	Elimination of Chlorine-Containing Oxidizers from Pyrotechnic Flare Composition (PP-1280)	SERDP	Ongoing
	Lead-Free Initiator Materials for Small, Electro-Explosive Devices for Medium-Caliber Munitions (PP-1306)	SERDP	Completed FY02
	Investigation of Alternative Energetic Compositions for Small Electro-Explosive Devices for Medium-Caliber Ammunition (PP-1307)	SERDP	Complete
	Medium-Caliber Lead-Free Electrical Primer (PP-1331)	SERDP	Ongoing
	Electrochemical Oxidation of Alkylnitro Compounds (PP-1345)	SERDP	Ongoing
	Environmentally Benign Impact-Initiated Devices Using Energetic Sol-Gel-Coated Flash Multilayers (PP-1362)	SERDP	Ongoing
	Environmentally Friendly Advanced Gun Propellants (PP-1363)	SERDP	Ongoing
	New Primary Explosives Development for Medium-Caliber Stab Detonators (PP-1364)	SERDP	Ongoing
	Non-Ozone Depleting Sealants for Ammunition Applications (PP-674)	SERDP	Completed FY96
	Tri-Service Green Gun Barrel (PP-1074)	SERDP	Completed FY02
	Synthesis, Evaluation, and Formulation Studies in New Oxidizers as Alternatives to Ammonium Perchlorate in DoD Missile Propulsion Applications (PP-1403)	SERDP	Ongoing, begun FY04
	Robust, Perchlorate-Free Propellants with Reduced Pollution (PP-1404)	SERDP	Ongoing, begun FY04
	Elimination of Red Water from TNT Manufacture (PP-1408)	SERDP	Ongoing, begun FY04
	Ordnance Manufacture, Maintenance, Use, and Surveillance to Enable Sustainable Ranges	ARMY	Ongoing, completion FY07
	Lead Free Projectiles for .22-Caliber Ammunition (PP-0203)	ESTCP	Ongoing, begun FY02
	Smoke and Dye Replacement (PP-0122)	ESTCP	Ongoing, begun FY02
	Nitrocellulose-Based Propellant Manufacturing Waste Minimization (PP-9804)	ESTCP	Ongoing
	Demonstration and Qualification of Small-Caliber Combat Ammunition Manufactured with Lead-Free Projectiles (PP-9901)	ESTCP	Ongoing
	Demonstration/Validation of Ultra-Fine Aluminum (UFAL) Production for Metastable Intermolecular Composition (MIC) Applications (PP-0205)	ESTCP	Ongoing
	Shock-Absorbing Concrete (SACON) Bullet Traps for Small-Arms Ranges (PP-9609)	ESTCP	Completed
	Close Loop Energetics with VOC Emission Reduction (CLEVER) (PP-9704)	ESTCP	Completed

5.0 TECHNOLOGY GAPS

There is no quantitative means by which to assess available technologies in relation to a user need, or specific requirement. One must weigh the requirement against costs, which include maintaining regulatory compliance, protection of human health and the environment, and impact to mission readiness. A matrix can be constructed to look at these various components, each assigned a weight according to priorities. While in the future this tool may become available for our use (Tankersley and Ford, 2004), a simpler technology assessment was performed which looked at the on-going RDT&E within DoD in each of the major categories and initial determinations made as to the applicability of the proposed outcome in relation to Navy requirements. From that, a first cut of gaps can be derived for each of the major areas, some more specific data than others. Priorities have not been assigned because the issues are so diverse in nature and vary throughout the community. The gaps identified thus far are presented below. They are intended to spur discussion among the members of the range sustainability community and to assist in focusing our attention on prioritization of issues with the goal of determining an overall RDT&E strategy.

5.1 Threatened and Endangered Species

Generally speaking, the on-going efforts are species, ecosystem and regionally (from regulatory standpoint) specific. Although some of the technology is transferable, the number of on-going TES issues is greater than those currently being addressed. The applicability of existing INRMPs was examined for identifying potential range sustainability data gaps for TES. The following generalizations are noted.

- **Noise.** Most of the INRMPs reviewed did not address the issue of noise regarding impact on TES. Noise may negatively impact some animal species, particularly during nesting or breeding seasons, and may even indirectly plant species due to altered foraging/seed distribution patterns of noise-impacted animals. The effects of noise on marine mammals, fishes, and turtles, while receiving considerable attention from the public, was not addressed in the INRMPs.

- **Soil and Water Contamination.** INRMPs did not specifically address the impact of spent ordnance and UXO on soil and water contamination, nor their impacts from potential ingestion by animals or uptake by plants and subsequent cumulative impacts in the food chain. It is likely that this information has been addressed in other documents, however, the findings of which may be incorporated into the INRMP.

- **Monitoring of Animals during Range Operation.** Most monitoring studies, primarily due to safety issues, take place during range inactivity. The impacts of range activity on sensitive species may not be immediately apparent by monitoring during range inactivity. Therefore, it would be beneficial to monitor sensitive species during range activity, or, if impractical, shortly after

range activity. The effects of range operations on marine mammals, fishes, and turtles is still a significant unknown, requiring further study which results in statistically significant, reliable, and defensible results.

- **Air Pollution.** INRMPs did not address this issue; while not expected to be a major contributor, quantitative estimates should be derived. Data from characterization of munition emissions can be used to provide scientifically defensible data on munitions to support continuance of live-fire training.

- **Military Mission.** INRMPs generally suggest an extensive variety of programs which could potentially clash with the military mission if fully implemented. While many INRMPs state that the recommendations are consistent with the military mission, few specifics are given which support this ideal and may result in an over-extended commitment.

- **Submarine Structures.** The ecological impacts of cables, conduits, seawalls and other structures were not typically addressed in the INRMPs reviewed. Abandonment of cables, laying of new cables and cable repair/maintenance have ecological impacts that may need to be covered as part of the INRMP.

- **Marine Habitat Designation.** Determination of federal, state, and tribal critical marine habitats needs to continually monitored for potential impacts to Navy range and transit operations. This also highlights the benefits of at sea ranges as marine preserves when compared to depleted habitats in other regions.

- **Comparison of Range Species with Equivalent Non-Range Habitat and Developed Non-Range Habitat.** Highlight the benefits of ranges as preserves, albeit somewhat degraded (though it has been seen that disturbance creates greater diversity), for species compared to developed areas.

- **Effect of Encroachment on Range Species.** Does encroaching development affect range diversity? That is, why are ranges singled out for conservation when densely developed urban areas often extend to base boundaries which results in encroachment issues for range operation, as well as degradation of overall habitat which may affect range species. Reduction of species diversity may be wrongly attributed to range activity in some cases.

Summary Gaps: Improved methods are required for TES and natural resource assessment, monitoring, and management. This may include, but limited to:

1. Development of an ecosystem "holistic" approach to species protection and viability, perhaps using innovative approaches such as animal landscape modeling, in lieu of traditional approaches.
2. Information on current policies and suggested improvements to methods for quantifying impacts of operational training and ordnance use on habitat and TES is needed.

3. Under RSEPA, endangered species are to be addressed under the NEPA process; however, there are general issues associated with assessing risk to endangered species. The ESA requires protectiveness of individual animals as well as populations. However, there is no effective process to assess risk to the individuals.
4. Relating to TES habitat: implement a long-term monitoring effort to document changes to the current and future conditions of three (minimally) separate targeted areas of research: (1) immediately offshore benthic habitat; (2) properties of the beach, physical and geological, and (3) the productivity and characterization of near-shore waters. This should be set up to actually examine the effects and impacts of episodic events vs. chronic trends.

5.2 Munitions Constituents and Perchlorate

The bulk of on-going RDT&E has been focused on munition constituents. A lot of recent attention has been focused on Perchlorate. There are numerous on-going efforts addressing characterization, fate and transport, and remediation of these contaminants. The following summary technology gaps have been identified to address munition constituents and perchlorate releases on operational ranges:

Summary Gaps:

1. Investigate technologies for the treatment of perchlorate-contaminated drinking water. Include review of existing and future technologies such as selective ion exchange resins to remove perchlorate from drinking water, modified granular activated carbon for drinking water treatment and remediation, and demonstration of a drinking water treatment using a biological process.
2. Develop Best Management Practices manual for operational ranges describing control procedures, available technologies, and other issues concerning MCs. Include descriptions of proven, experimental, and new R&D technologies for implementation on DON/USMC ranges. Include scientifically defensible risk-based DoD range clearance guidance and management procedures. Involve Navy EOD and UXO contractor participation in improved, range clearance operations designed to minimize munition constituent contamination. Suggest improved policies and technologies for tracking range and ordnance use.
3. Detail workable management solutions for mitigation of MCs off range. Include review of existing and future technologies such as groundwater well injection, bioremediation, surface application of lime, low cost electron donor application, and other methodologies.
4. Investment in technological development of more complete emission capture and control from range and site ordnance destruction in order to minimize OB/OD contamination to air and ground (see also air pollution).
5. Prioritization of MCs in regards to those most likely to occur on Navy/USMC ranges, and toxicity.

5.3 Protected Marine Resources

The Navy is devoting significant resources to RDT&E relating to marine mammal issues, and is also conducting MRAs and MSDDs. It was outside the scope of this IDR to look into these areas. There are gaps identified in the MRAs for consideration. One area receiving less attention is that of coral reefs and other marine habitats. Improved capabilities are still required for rapid and cost-effective monitoring and inventorying of coral reefs. There are a few new projects looking at coral reefs. If these programs are successful and implemented, with increased monitoring, specific issues may arise which require additional RDT&E. It still needs to be determined if assessment and monitoring techniques for coral reefs and other potentially impacted habitats are adequate weighed against increased scrutiny by the regulatory community.

Summary Gap: Provide coordination for upcoming DoD-funded R&D on coral reef assessments, and define how to codify, acquire or transition this technology for implementation by Natural Resource managers at affected Navy Regions.

5.4 Air Pollution

Emissions from jet aircraft engines are a top environmental issue. There are a fair number of on-going projects which look into dust control, air quality modeling, dust emission characterization, emissions from DoD emissions, GIS tools, and OB/OD issues. There are still some data gaps to be examined.

Summary Gaps:

1. Characterization, control, and transport of HAPs from OB/OD.
2. Air emissions from total range-related aircraft operations (i.e., to/over/from ranges) are yet to be defined for ranges.
   - New methods for measuring emissions are needed.
   - Legacy and new military engine characterizations needed.
3. Air emissions from fire-fighting exercises are unresolved.
4. Improved air quality modeling capability to determine impact of air emissions on range air quality before/during/after events.

5.5 Noise Pollution

Aircraft noise is a top NAVAIR environmental issue. The majority of the on-going efforts use models for forecasting and assessing noise impacts; new range design to minimize noise impacts; and management options for noise control.

Two SERDP research projects have focused on determining the effect of noise from DoD operations on endangered species. "The Effects of Aircraft Overflights on Birds of Prey" is an Air Force project addressing the effect of military aircraft overflights on raptor populations. It includes such factors as habitation, prey abundance, and changes in parental behavior and observed behaviors and responses of nesting raptors during aircraft overflights. Researchers developed a unique ANM for remote noise data collection and a dose response model to assist planners in conducting environmental impact analyses.

"Assessment of Training Noise Impact on the Red-Cockaded Woodpecker" is an Army project to determine the impact of military training noise, such as artillery, small arms, helicopter, and maneuver noise, on the red-cockaded woodpecker. Results from this project indicated that training noise has no significant impact on the reproductive success of the red-cockaded woodpecker.

Summary Gaps:

1. Develop in-flight noise reduction technologies.
2. Measure magnitude and directivity of noise from in-flight aircraft.
3. Develop improved noise abatement devices for aircraft engine ground testing and operations.
4. Develop practical acoustic models for generation and propagation of noise from high-thrust, vectored jet engines.
5. Waterborne noise – effect of sonar on sea mammals is being addressed by ONR. Other effects on species of concern unknown.

5.6 Range Management

5.6.1 Range Residue. Range residue and scrap, commonly referred to as material that presents a potential explosive hazard (MPPEH), is a significant issue for range sustainability. Each range is essentially left to manage its own waste material without guidance and minimal funding. Many ranges have difficulty managing range residue and scrap material because of a lack of recognized and approved methods for removal and processing. This deficiency has resulted in significant stockpiles at RHAs and on the ranges themselves.

Significant efforts by a few Navy and Marine Corps bases have lead to the development of technology and methods for the safe processing of MPPEH. However, further efforts are required to develop and implement improved techniques at ranges with little processing capability and management resources.

Summary Gaps: The gaps identified in this document are outlined below:

1. Provide compliance and technical guidance on management of MPPEH and other range residue on operational ranges. The guidance will document and define current and future environmental liabilities (e.g., CERCLA) from MPPEH contamination. Also included will be information on purchasing/contracting specialized processing equipment for short and long-term range clearance operations, RHAs, and demilitarization, including identification of funding and training availability;
2. Develop a best management practices document to detail policies and procedures on how to manage, certify, and process to ensure no MPPEH, and assist in reduction of MPPEH stocks on ranges;
3. Develop DoD performance specifications to encourage innovation from contractors involved in clearing, storing, certifying, demilitarizing, and disposal/recycling of MPPEH;
4. Increase capabilities of existing procedures and processing technologies. Demonstrate improved state-of-the-art processes and management of MPPEH acquisition of processing equipment;

5. Develop mobile systems for on-site processing at RHAs; and
6. Create a cost analysis tool to assist range managers select the most cost-effective and appropriate methods and technologies for their ranges.

5.6.2 Risk Assessment. The following discussion covers both human health risk and eco-risk assessment. The initial bulleted items discuss some general issues with the RSEPA process and how additional information may be useful to maximize its success. Specific issues facing the Navy associated with assessing risk to either human health or the environment at the various active range environments are also included.

5.6.2.1 Issues Associated with Migration of Constituents from Active Ranges

- As a part of the RSEPA, an RCA is performed every five years to determine, in part, if further analysis is required to assess risk of any off-range release. Prior to any sampling effort, predictive modeling will be done, utilizing available data on the munitions, to predict migration off range and the potential concentrations. Currently only groundwater fate and transport predictive modeling has been utilized at a Navy site to model MCs. Assessing the fate and transport for soil and surface water is also required. Although there are a number of predictive models that will provide a concentration that can be compared to the screening values, it is unknown which model is more accurate and realistic. Additional work is needed to verify the existing models to determine which models are the best for predicting fate and transport.

- Field sampling events are problematic at active ranges due to worker safety issues and the scheduling around or disruption of range activities. As a result, the use of field screening tools is desirable to ensure that adequate and appropriate samples are collected in as few field events as possible. There are field screening tools for MCs; however they are in various stages of maturity.

- Currently, there is no EPA-approved method for quantifying perchlorate in surface water, nonpotable groundwater, or soil samples. However, efforts are under way in both EPA and the private sector to develop alternative methods with improved sensitivity and specificity for perchlorate in environmental samples. Alternative analytical methods with improved sensitivity and specificity are commercially available on a limited basis; however, none has yet been published or approved for use by EPA (U.S. Navy, 2003).

- Additional studies in the distribution and metabolism of TNT into its breakdown products are needed to better understand fate, transport, and toxicity to humans and the ecosystem.

5.6.2.2 Issues Associated with Assessing Human Health Risk at Active Ranges

- There are a significant number of data gaps in the available munitions constituent screening values or benchmarks for the human health risk assessment.

Some of these data gaps were identified in Table 7 of the January 2004 RSEPA Policy Implementation Manual and are reproduced here as Table 5-1.

- Standard exposure parameters for the munitions response workers for preliminary screening need to be developed, particularly when the area will remain active/industrial.

- Insufficient site-specific exposure data leads to overly conservative exposure scenarios. The use of default exposure parameters compound the conservatism. However, without well documented site-specific parameters, the default parameters are the only ones available. More work is needed on defining a reasonable methodology for establishing and defending realistic site-specific exposure scenarios.

- Some of the carcinogenicity studies done prior to 1990 should be reviewed. Due to a limited understanding of the carcinogenic process, many early studies often overestimated cancer risk. Recently reevaluated studies have shown RDX cancer risk was shown to be too high, the RDX RfD was probably too low and the 1,3,5-TNB RfD was increased significantly.

5.6.2.3 Issues Associated with Assessing Ecological Risk at Active Ranges

- There are a significant number of data gaps in the available toxicity data for the MCs for various species. Some of these data gaps are identified in Table 5-2. Additional toxicity data needs include:

  — Acute and subchronic studies, designed with the proper QA/QC to derive defensible toxicity reference values (TRVs). There is a need for at least one good study for one species for each vertebrate class.
  — Toxicity studies are needed to identify the target or sensitive organs that are impacted by each munitions constituent by species. The focus needs to be on identifying toxic effects rather than measuring toxic exposures.
  — Chronic toxicity data is needed on the long-term effects from the exposure of MCs.

- The Army Center for Health Promotion and Preventative Medicine (CHPPM) produced a report in March 2002 titled *Bioconcentration, Bioaccumulation and Biomagnification of Nitroaromatic and Nitramine Explosives and their Breakdown Products* (Toxicology Study 87-MA-4677-01). This report identified the available bioavailability information for TNT, RDX, HMX and their breakdown products and made general conclusions. Current risk assessment practice for determining exposure and effects of contaminants to the higher trophic levels is done through modeling. Additional studies are needed to confirm and improve the bioavailability and trophic transfer data to reduce the conservative assumptions that are currently used in the modeling. In addition, guidance is needed on making the models more site-specific and verifying the accuracy of the models for MCs.

Table 5-1. Screening Values for Munitions Constituents

Analyte	Abbr.	CAS Num.	Reporting Limit				Human Health Screening Values				Federal Ambient Water Quality (µg/L)		Sediment Quality Benchmark (mg/kg)[3]
			Ground Water (µg/L)	Surface Water (µg/L))	Sediment (mg/kg)	Soil (mg/kg)	Residential Soil[1] (mg/kg)	Cancer/ Non-Cancer	Industrial Soil[1] (mg/kg)	Ground Water (µg/L)	CMC[2]	CCC[2]	
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4	0.1	0.3	0.01	0.01	4	C	16	0.61[1,4]	4000[5*]	190[6*]	0.190
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0	3	3	0.05	0.05	3100	NC	31000	400[7]		330[6*]	0.330
2,4,6-Trinitrotoluene	2,4,6-TNT	118-96-7	0.03	0.03	0.01	0.01	16	C	60	2.2[1,4]	560[5*]	<40[5*]	0.13
Perchlorate		7601-90-3	See Section 3.3.3.3							1 – 18[8]			
1,3,5-Trinitrobenzene	1,3,5-TNB	99-35-4	0.03	0.03	0.02	0.02	1800	NC	18000	1100[1,4]	30[6*]	14[6*]	0.02
1,3-Dinitrobenzene	1,3-DNB	99-65-0	0.09	0.09	0.02	0.02	6	NC	60	1.0[9]	110[6*]	30[6*]	0.04
2,4-Dinitrotoluene	2,4-DNT	121-14-2	0.02	0.02	0.02	0.02	120	NC	1200	5.0[7]	0.11[10]		0.230
2,6-Dinitrotoluene	2,6-DNT	606-20-2	0.01	0.01	0.02	0.01	60	NC	600	5.0[7]	18,500[5*]		18.5
2-Amino-4, 6-dinitrotoluene	2-Am-DNT	355-72-78-2	0.1	0.1	0.02	0.02							
2-Nitrotoluene	2-NT	88-72-2	0.09	0.09	0.02	0.02	370	NC	1000	61[1,4]			
3-Nitrotoluene	3-NT	99-08-1	0.09	0.09	0.02	0.02	370	NC	1000	61[1,4]			
4-Amino-2,6-dinitrotoluene	4-Am-DNT	1946-51-0	0.1	0.1	0.05	0.05							
4-Nitrotoluene	4-NT	99-99-0	0.09	0.09	0.05	0.02	370	NC	1000	61[1,4]			
Nitrobenzene	NB	98-95-3	0.03	0.03	0.02	0.02	20	NC	100	3.4[1,4]	27,000[6*]		27.0
Nitroglycerin	NG	55-63-0	0.09	0.09	0.05	0.05	30	C	120	4.8[7]	1,700[5*]	200[5*]	
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8	0.5	0.5	0.02	0.02							

1. EPA Region 9 Preliminary Remediation Goal Tables (10/01/02) (www.epa.gov/region09/waste/sfund/prg/index.htm).
2. CMC, the criteria maximum concentration, will protect against acute effects in aquatic life and is the highest in-stream concentration of a priority toxic pollutant consisting of a 1-hour average not to be exceeded more than once every 3 years on average. CCC, the criteria continuous concentration, will protect against chronic effects in aquatic life and is the highest in-stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every 3 years on average.
3. Calculated from water toxicity data based on 1% organic matter according to Talmage S.S., and D.M. Opresko, 1995, Draft Ecological Criteria Documents for Explosives, Oak Ridge National Laboratory, Oak Ridge TN.
4. EPA Region 6 Corrective Action Strategy, EPA Region 6, Dallas TX, November 2000.
5. Burrows, E.P., D.H. Rosenblatt, W.R. Mitchell, and D.L. Parmer, 1989, Organic Explosives and Related Compounds: Environmental and Health Considerations, U.S. Army Biomedical Research and Development Laboratory.
6. Talmage, S.S., and D.M. Opresko, 1995, Draft Ecological Criteria Documents for Explosives, Oak Ridge National Laboratory, Oak Ridge TN.
7. U.S. Environmental Protection Agency, Summer 2000, Drinking Water Standards and Health Advisories, EPA 822-B-00-001, Office of Water, Washington, DC.
8. Currently proposed, state and federal advisory limits for perchlorate range from 1 to 18 µg/L. These health risk values continue to be developed.
9. Roberts, W.C., and W.R. Hartley, editors, 1992, *Drinking Water Health Advisories: Munitions*, U.S. EPA Drinking Water Health Advisories, Lewis Publishers, Boca Raton, FL, 535 pp.
10. Human Health for Consumption of Water and Organism, U.S. Environmental Protection Agency, National Recommended Water Quality Criteria: 2002 Office of Water, Washington, DC, EPA-822-R-02-047

* Lowest observed adverse effect level (LOAEL). Not enough data to develop criteria.

Source: RSEP A Appendix D-QAPP (U.S. Navy, 2003).

Table 5-2. Munitions Constituent Toxicology Data Gaps for Ecological Risk Assessments[a]

					Invertebrates				
Compound	**Plants**	**Mammals**	**Birds**	**Fish**	**In Soil**	**In Water**	**In Sediment**	**Reptiles**	**Amphibians**
TNT	Acute toxicity data for ryegrass and alfalfa[b] Substantial Bioaccumulation studies in plants[c]	Sufficient for TRV (many rodent, other mammal species, one wildlife species	Sufficient for TRV (two species, one wildlife, feeding and gavage studies.	Acute toxicity data for several species	Acute/chronic data for earthworms	Acute toxicity data for several species	Acute/chronic toxicity data for amphipods and polychaete	One acute study: **insufficient data available**.	One study with only one dose and no observed adverse effects level (NOAEL): **insufficient data available**
2,4-Dinitro-toluene	(a)	Sufficient for TRV.	One wildlife study in progress.	Acute toxicity data for redfish	Acute data for earthworms; chronic underway: currently unpublished	Acute toxicity data for several species	No Data	One acute study: **insufficient data available.**	One study with multiple treatments. Sufficient for soil screening.
2,6-Dinitro-toluene	(a)	Sufficient for TRV.	No Data	Acute toxicity data for redfish	Acute/chronic data for earthworms finished but: currently unpublished	Acute toxicity data for several species	Acute toxicity data for amphipod	No Data	No Data
RDX	Short-term screening bioassay developed for 15 terrestrial plants **; Bio-accumulation factors devel-oped for sunflower plants ***; On-going study developing bioaccumulation factors in 2 terrestrial plants – **additional research needed**	Sufficient for TRV.	One feeding study. Sufficient data for TRV.	Acute toxicity data for several species	Acute/chronic data for earthworms	Acute toxicity data for several species	Acute/chronic toxicity data for amphipods and polychaete	One acute study: **insufficient data available.**	One study with multiple treatments. Sufficient for soil screening.
HMX	On-going study developing bioaccumulation factors in 2 terrestrial plants – **additional research needed**	Many mammalian data, however, acute rabbit data suggest possible sensitive species.	One study (limit test and 28 oral) in Northern Bobwhite. Sufficient data for TRV.	Acute toxicity data for several species	Acute/chronic data for earthworms	Acute toxicity data for several species	Acute/chronic toxicity data for amphipod and polychaete	No Data	No Data
PETN	(a)	Mammalian data lacking, however, **TRV is available but questionable**.	No Data	No Data	(a)	Acute toxicit y data for copepod	No Data	No Data	No Data
Picric Acid	(a)	Mammalian data lacking, however, **TRV is available but questionable.**	No Data	Acute toxicity data for redfish	(a)	Acute toxicity data for several species	Acute toxicity data for amphipod	No Data	No Data

Table 5-2. Munitions Constituent Toxicology Data Gaps for Ecological Risk Assessments (page 2 of 3)

					Invertebrates				
Compound	**Plants**	**Mammals**	**Birds**	**Fish**	**In Soil**	**In Water**	**In Sediment**	**Reptiles**	**Amphibians**
Nitroglycerin	(a)	Data adequate for TRV.	No Data	No Data		No Data	No Data	No Data	No Data
Trinitro-benzene	(a)	Sufficient for TRV (many rodent, other mammal species, one wildlife species	No Data	Acute toxicity data for sheepshead minnow* and redfish	Acute/chronic data underway with earthworms	Acute toxicity data for several species	Acute/chronic toxicity data for amphipod and polychaete	No Data	No Data
Dinitro-benzene	(a)	Sufficient for TRV, however, medium confi-dence in TRV.	No Data	Acute toxicity data for redfish	(a)	Acute toxicity data for several species	No Data	No Data	No Data
Tetryl	(a)	Sufficient for TRV, however, medium confi-dence in TRV (no wildlife data).	No Data	Acute toxicity data for redfish	(a)	Acute toxicity data for several species	Acute toxicity data for amphipod	No Data	No Data
Perchlorate	(a)	Sufficient data exists for TRV derivation	Study in progress (McNabb; Northern Bobwhite).	No Data	No Data	No Data	No Data	No Data	Data available for water exposures (Texas Tech).
2-Amino-dinitro-toluene	(a)	Data available suggest substance is not bioavailable (a)	Data available suggest substance is not bioavailable (a)	Acute toxicity data for fathead minnow and sheepshead minnow*	Earthworm Contact toxicity (acute, no soil) only	Acute toxicity data for several species	No Data	(a)	(a)

Table 5-2. Munitions Constituent Toxicology Data Gaps for Ecological Risk Assessments (page 3 of 3)

					Invertebrates				
Compound	**Plants**	**Mammals**	**Birds**	**Fish**	**In Soil**	**In Water**	**In Sediment**	**Reptiles**	**Amphibians**
4-Amino-dinitro-toluene	(a)	(a)	(a)	Acute toxicity data for several species	Earthworm Contact toxicity (acute, no soil) only; in SERDP report	Acute toxicity data for several species	No Data	(a)	(a)
2,4-Diamino-nitrotoluene	(a)	(a)	(a)	Acute toxicity data for sheepshead minnow*	(a)	Acute toxicity data for oyster larvae and copepod	Acute/chronic toxicity data for amphipod and polychaete	(a)	(a)
2,6-Diamino-nitrotoluene	(a)	(a)	(a)	No Data	(a)	No Data	No Data	(a)	(a)
Nitro-guanidine	(a)	(a)	(a)	No Data	(a)	Acute toxicity data for copepod	No Data	(a)	(a)
Diphenyl-amine	(a)	(a)	(a)	No Data	(a)	Acute toxicity data for several species	No Data	(a)	(a)
2-Nitrotoluene	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
3-Nitrotoluene	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
4-Nitrotoluene	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Ammonium Picrate	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Nitrobenzene	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Nitrocellulose	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

Note: If there was no information available on the status of the data, the cell was left blank. If it was known that there is no data, then "No Data" was put in the cell.

(a) Note that blank cells indicate a lack of knowledge on the status of data and not a lack of data.

(b) Information from Sustainable Range Management Conf, 6-8 Jan 2004. Paper by Dr Elly Best *Toxicity and Residues of Aged TNT in Plants and Worms*.

(c) *Bioconcentration, Bioaccumulation and Biomagnification of Nitroaromatic and Nitramine Explosives and their Breakdown Products*, The Army Center for Health Promotion and Preventative Medicine (CHPPM), March 2002, Toxicology Study 87-MA-4677-01.

* Study has been completed but the data has not been published as of 12/10/03.

** Study completed, draft journal accepted for publication in 2004 – *Ecotoxicology*.

*** Study completed, draft journal submitted; responding to editors comments- *Ecotoxicology*.

- In addition to munition constituents, there are toxicity data gaps for munitions associated metals used in bullets, signaling flares, igniters, tracers, explosives, primers, boosters, detonators, and casings. Additional plant and invertebrate toxicity data is needed to establish ecological soil screening levels in accordance with EPA's Eco-SSL protocols for antimony, silver, barium, chromium (VI), and nickel.

- Impacts of munitions and their constituents to marine mammals in the open ocean are largely unknown. As a result, the ability to assess risk is problematic. Additional studies are needed to determine the impacts and effects of MCs to these animals.

- There is a lack of data on the munitions constituent impacts to unique marine environments including coral reef systems and critical sea grass beds.

- The carrying capacity of MCs in various ecosystems is largely unknown. Nature generally has the ability to handle a certain level of contamination without impact to the environment. Exceedances of these levels are an indication that there is a potential impact. The lack of knowledge on the specific levels leads to potentially overly conservative assumptions regarding the impact of munitions constituent concentrations in the environment.

- Although under RSEPA, endangered species are to be addressed under the NEPA process, there are general issues associated with assessing risk to endangered species. The ESA requires protectiveness of individual animals as well as populations. However, there is no effective process to assess risk to the individuals.

Summary Gaps: There is a significant amount of research occurring within DoD to address issues associated with perchlorate; TNT, RDX and HMX; and their breakdown products. Therefore, it is recommended that the Navy efforts focus on the more Navy-specific issues. The following are recommended Navy priority requirements for addressing data gaps in assessing risk at active ranges:

1. Development of and verification of fate and transport predictive models for surface water and soil pathways.
2. Improved field screening tools for measuring MCs at sufficiently low detection levels to perform risk assessments.
3. More work is needed on defining a reasonable methodology for establishing and defending realistic, consistent site-specific exposure scenarios for both human health and ecological risk assessments.
4. At least one good acute and subchronic study, designed with the proper QA/QC to derive defensible TRVs is needed for plants and animals associated with Navy unique environments such as marine mammals, coral reef systems and critical sea grass beds with a focus on the key Navy aquatic MCs.
5. For each major munitions constituent, at least one good acute and subchronic study, designed with the proper QA/QC to derive defensible TRVs is needed for each vertebrate class and plants.

6. Toxicity studies are needed to identify the target or sensitive organs that are impacted by each munitions constituent by species. The focus needs to be on identifying toxic effects rather than measuring toxic exposures.
7. Chronic toxicity data is needed on the long-term effects from the exposure of MCs.
8. The development of Human Health Benchmarks for each major munitions constituent for both soil and water exposures.

5.6.3 GIS. Although there are numerous efforts on-going (most of which are not identified under RDT&E efforts, but individual service/installation efforts), standard methods are needed for data gathering, analysis, display and sharing.

Summary Gap: Provide guidance on application of GIS to operational ranges for Navy range personnel to include training resources, availability of data layers, coordination of Navy-wide GIS efforts, and identification of associated costs. Coordinate application of GIS with NRO for service-wide standardization. No new RDT&E needed at this time.

5.6.4 Invasive Species. There are several on-going efforts within SERDP and the Army. These efforts do not focus on estuarine/coastal species of concern to the Navy. Data is lacking for cost-effective prevention, management, and control of Navy-unique invasive species. Technology transfer of current SERDP/Army efforts for terrestrial invasive species of concern needs to be maximized.

Summary Gap: Determine strategy for control of *Phragmites* at Dare County Range; current methods are labor-intensive; funds not available for adequate control on a recurring basis. Identify other unique species of concern. Develop prevention, management and control plan.

5.6.5 Undersea Cables. No on-going RDT&E has been identified.

Summary Gap: Define potential environmental issues for undersea cables placement at operational ranges. Define regulatory issues, potential construction and long-term environmental concerns, installation and removal technologies, and provide recommendations for solutions least disruptive to underwater habitat. Explore and scientifically document long-term consequences for leave-in-place cable scenarios.

5.6.6 Urban Encroachment and Cultural Resources. There are a few efforts underway, through modeling, to look at alternate future scenarios to predict impacts to bases from development outside the fence line. Cultural resources were included in this effort. Another effort used modeling to help assess risk to buried resources. It is unknown how well these efforts have been transferred to the Navy community. Another study resulted in a risk-based approach to both natural and cultural resource management on military installations. It is unknown if any Navy users require this technology.

Summary Gap: No specific gaps are identified that require further RDT&E at this time. No new technology alternatives are recommended at this time.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

While initial DoD-wide efforts in range sustainability have focused on policy implementation and legislative changes, there are numerous ongoing and planned RDT&E efforts tasked with answering a broad range of questions, from sensor development to environmental impact. The bulk of range sustainability funding has come from the DoD's SERDP/ESTCP program and Army-specific programs. Navy funding in this field has been focused on marine mammal issues, in-water munition constituent fate and effect, and underwater corrosion and munitions transport.

Some technologies are in the early stages of development, and it is uncertain whether the product will fulfill Navy objectives from a technological, management and implementation perspective. Equally important, it is not known whether they can be readily applied to Navy ranges, or will they require modification for Navy ranges. Regulatory and public acceptance of these new programs is untested, as well.

Because of the diverse nature of the needs identified in this report, coupled with numerous potential DoD wide RDT&E program areas, significant discussions must be conducted before an integrated Navy RDT&E investment strategy for the environmental issues addressed herein can be finalized. Another factor influencing investment strategy is the accumulation of new information being gathered through the TAP program. This includes data and lessons learned from studies recently initiated under RSEPA and REVA, RCMPs, MSDD and MRAs.

Finally, extensive coordination with other services on current and planned efforts should be an immediate goal in order to gain maximum leveraging of existing funds, avoid duplication of effort, share expertise, identify program areas applicable for DoD-wide implementation, and identify programs uniquely suited to Navy needs.

6.2 Initial Program Recommendation

There are five recommended new starts for consideration. They were chosen based upon high rankings they received by various functional work groups. The first program, which looks at the environmental effects of undersea cables, has already been initiated due to its high priority. The proposed plan of action is provided for your information. Follow-on efforts which may be required have not been identified.

Title: Preliminary Environmental Analysis of Navy Seafloor Cables

Background: During the late 1990s and continuing into the early years of the 21st century, marine telecommunications was one of the fastest growing areas of ocean technology worldwide and is going strong today. With the increased installation of seafloor communications cables in recent years, regulatory agencies, environmental groups, and fishing groups have responded with a heightened attention and interest in the installation and removal of these seafloor cables.

Current Navy and industry practice is to abandon in- place out-of-service seafloor cables. However, due to this increased awareness by the regulatory community, the Navy is being directed to remove out-of-service cables before new cables can be installed, thus impacting mission readiness. Additionally, there are increased compliance and permitting requirements for new Navy seafloor cable projects, thereby significantly increasing the time it takes to complete an installation. These increasingly stringent requirements are based primarily upon the belief that if it is man-made, it must be bad and therefore does not belong on the seafloor and should be removed when its service life is complete. However, there is very little scientific information on the actual environmental impacts of the installation of seafloor cables, their subsequent maintenance, repair, and final disposition.

The potential environmental, financial and operational impact on the Navy of removing all out-of-service seafloor cables is significant. This project is focused on providing the Navy and the regulatory community pertinent information with which to make scientifically based decisions on the disposition of out-of-service seafloor cables, as well as on siting and installing new seafloor cable.

Regulatory Drivers: The Navy and other federal agencies have regulatory compliance requirements when installing hardware such as seafloor cables in nearshore and in deep water environments. In response to the increased rate of installation of commercial communications cables, regulatory agencies and the National Marine Sanctuaries have increased their awareness and permitting requirements for the installation of seafloor cables. In some cases this has effectively blocked planned installation routes and required the addition of unplanned efforts, raising project costs by 20% to 40%. The Navy has a vast number of seafloor cables (estimates of installed cables exceed 40,000 nautical miles) that provide numerous functions such as Navy communications, at-sea training, surveillance, etc. These cables sometimes need to be repaired, replaced, upgraded and new cables need to be installed to meet the changing requirements of the Navy. Recently, Navy projects such as the FOCUS Cable Repair and STARS have been subject to increased regulatory constraints. If not addressed these new regulatory constraints could impact Navy operations and range readiness and sustainability. Table 6-1 identifies the environmental regulatory framework for the installation of seafloor cables.

Objectives: The objectives of this project are to:

1. Investigate and understand the material components used in Navy seafloor cables. This will include looking at past, present, and future (if available) Navy seafloor cable designs,
2. Assess the materials used in Navy seafloor cables for their potential to adversely impact the marine environment, and
3. Investigate Navy and commercial practices for seafloor cable installation, removals, and justification for abandoning in-place after their operational lifetime.

The final outcome is to provide the Navy a scientific basis for making sound decisions for balancing long-term disposition of seafloor cables in the marine environment.

Table 6-1. Environmental Regulatory Scheme for Installation and Removal of Seafloor Cables

State Requirements: State waters extend from shoreline out to 3 nm.	
Coastal Zone Management Act (CZMA)	States have jurisdiction over submerged lands subject to U.S. navigation out to 3 nm. Some states such as California try to extend their influence out to 12 nm and also inland for watersheds and rivers that drain into the coastal zone. Cable projects within state jurisdiction usually require consultation and permitting with State Coastal Commission under CZMA.
State Lands Department	For cable projects that come ashore (shore landings) may require consultation and permitting with State Lands Department. Big issue in HI for native burials that often occurred along the coastline.
Federal Requirements: Federal waters extend from 3 nm to 200 nm offshore.	
National Environmental Policy Act	Applicable only to cable installation projects that occur within 12 nm of shore.
Executive Order 12114 Environmental Effects Abroad Major Federal Actions	Furthers the implementation of NEPA and applies to cable installation projects that extend past 12 nm.
Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA)	Ensure the installation and removal of submarine cables will not adversely impact any marine mammals and species (flora/fauna) listed as threatened or endangered. If impacts are identified then consultation under the ESA or MMPA will be required.
Army Corps of Engineers and Clean Water Act (CWA)	Have jurisdiction over the navigable waters of the U.S. Permitting either under Army Corp Nationwide permits or individual permit may be required.
Executive Order 13089 Coral Reef Protection	Avoid any impacts to coral for installation and removal of submarine cables. NOAA is the lead agency for the implementation of this E.O.
National Preservation Act and Shipwreck Preservation Act	Avoid impact to shipwrecks and areas of archeological significance.
E.O. 13007 Indian Sacred Sites	Avoid any impact to Indian sacred sites.
E.O. 13158 Marine Protected Areas	Installation cables in Marine Protected areas may require additional consultation and mitigation measures
National Marine Sanctuaries (NOAA)	Operated under the jurisdiction of NOAA. Cable projects should avoid these sanctuaries for they will most likely have stringent requirements and mitigation measures for submarine cables including monetary assessments. Some sanctuaries for bid submarine cables
Special Interest Groups and NGOs	
Fishing Groups	
Tribes	
Environmental Organizations	
Cable Companies and Associations	

nm = nautical miles.

Approach:

Technical

Objective 1: Perform literature review of cable types and their constituents; obtain cable specifications from user community; contact industry suppliers; contact appropriate Navy experts.

Objective 2: Perform technical assessment of cable constituents and their potential to impact the marine environment. This will be done through a paper search and by

conducting a case history review to see if any field studies have been initiated on cables in place. Integrate with existing cable programs with high level of planned inspections for data collection opportunities. Identify technical gaps that need to be evaluated in future field studies.

Objective 3: Perform case history review of both cable installation and removal projects for best management practices. Assess impact of leaving cable in-place versus removal. Determine existing cable removal techniques, disposal, and costs associated with each stage. Integrate with existing projects for initial data gathering/baseline data opportunities.

Regulatory

In order to support all objectives, an understanding of the regulatory basis/framework for seafloor cable installation, repair, and disposition (abandon in-place or removal) will be completed. Stakeholders will be identified from the regulatory and Navy communities. Input from Navy stakeholders and the scientific community will be solicited through the publication/advertisement of this report's intent, scope, and data gaps (such as *Currents Magazine* and other professional society journals and newsletters).

Additionally, two reviews (initial development and final review) will be held with Navy stakeholders. One technical workshop will be held (possibly in conjunction with a professional society conference) to bring in experts in the fields of seafloor environmental science to review our findings and solicit input on the potential impacts of seafloor cables. The workshop will include a summary of the scientific and engineering principles of seafloor cable design, installation, and repair, but will focus on environmental issues related to removal, abandon-in-place and final disposal of out-of-service cables. Table 6-2 lists potential stakeholders. The purpose will be to bring in the Navy stakeholders to help scope the issues and help collect relevant existing technical data that this preliminary analysis must capture, and then to conduct a final review of the draft results. Where appropriate this project will be briefed/discussed at existing workshops and conferences to leverage additional input from the scientific and environmental community.

Table 6-2. Related Groups, POCs, etc.

Stakeholders - Cable Owners	RCC-USG, Underwater Systems Group of the Range Commanders Council	Meetings 11/18/03, 4/04 and 10/04
	FOCUS cable landing relocation project experience Commander Undersea Surveillance (CUS)	Tony Parisi
Stakeholders – Other Federal	NOAA (Environmental data and regulatory – National Marine Sanctuaries)	
	ACOE ((Environmental data and regulatory)	Mark Sudol
Stakeholders - Industry	ICPC, International Cable Protection Committee	Private Website Section; Environmental Advisor – Dr. L. Carter
	NASCA, North American Submarine Cableowners Association	
Stakeholders – Professional Societies	Marine Technology Society	Underwater Intervention Conference 2/04; Domestic Symposium, 9/04; OCEANS-04, Japan 11/04

Schedule

Phase	Task	Completion Date
1	Develop Project Plan based on Stakeholder review input	17 Dec 03
2	Develop initial framework for the Preliminary Assessment Report Guide (scoping of issues) and regulatory framework and coordinate with Navy stakeholders for feedback	Feb 04
3	Gather Navy seafloor cable designs (best available data)	March 04
4	Perform case study review and literature search on best practices for cable installation, repair, and disposal (abandon in place or remove)	May 04
5	Assess potential impact to marine environment from cable materials	July 04
6	Hold Technical Workshop	August 04
7	Submit Report to Navy stakeholders for input	Nov 04
8	Provide Final Report	30 Dec 04

Final Product: The final report of this task will integrate all the technical information obtained from the stakeholders, case studies, literature searches along with defining applicable regulations and permitting process. The final report will also provide a siting requirements checklist, inspection/maintenance requirements (to provide defensible basis for leaving in-place and/or make it easier to remove when required to do so), and removal and disposal options with supporting scientific data. This report will be in linked hyper-text document format, for user-friendly access (from website) and utilization.

Funding: $100 K

6.3 New Starts

The proposed new starts are:

1. RSEPA RCA Fate and Transport Modeling
2. Enhanced Range Scrap Processing Recycling of Range Scrap Ordnance
3. Animal Landscape Modeling
4. Ecological Soil Screening Levels for Invertebrates and Plants Exposed to Munition Constituents

6.3.1 RSEPA Range Condition Assessment Fate and Transport Modeling. This project is under consideration for funding due to the high priority set the RSEPA workgroup.

Description: As part of the Range Sustainment Environmental Program Assessment (RSEPA), a RCA is to be performed every 5 years at each land-based Navy range. The RCA report must be able to answer the following two questions: (1) Are further steps required to maintain compliance, and (2) Is further analysis required to assess risk of off-range release? Prior to any sampling effort, predictive modeling will be used to help answer question number 2. The specific model to be used must be able to take data from the various classes of munitions used at the range and predict whether or not the concentrations of the constituents left in the soil are transporting (both horizontal and

vertical) off range. The model used should allow for a range of assumptions based on the site conditions (i.e., soil type, average rainfall, etc).

Currently any predictive modeling that has been utilized at a Navy site to model MCs has involved only groundwater transport. The RCA includes fate and transport for land, groundwater and surface water. Although there are a number of predictive models that will provide a concentration for comparison to screening values, because of lack of experience it is unknown which model is able to produce the most accurate and realistic results. As such, it would be a great benefit to the program if various models were compared against each other and recommendations were made as to which one would be most appropriate for our purpose.

6.3.2 Enhanced Range Scrap Processing Recycling of Range Scrap Ordnance. This project ranked 45.3 (#1 by RSG), and ranked 43.1 (#1 of 21 by FAC HW/P2/Ord MFT). The initial requirement was identified by Polly Kendal CINCLANTFLT, Norfolk. Due to the high ranking in two functional work groups, this project is under consideration for funding. A description of the project is below.

Problem Statement: The Navy and Marine Corps are spending millions of dollar annually disposing of contaminated range scrap resulting from range maintenance activities in accordance with the Draft DoD policy, Range Clearance on Operational Ranges. Items being removed from ranges such as targets, casing fragments, tires, etc., may contain explosive residual and must be treated and certified prior to disposal or recycling. Current methods for addressing range materials are labor-intensive, cumbersome, and costly, and often leave residual contamination in the material pores or hard-to-reach equipment surfaces. Methods such as open burning are effective, but treated materials are generally not suitable for reuse and open-burn facilities are difficult to permit. The Navy needs an efficient, cost-effective, mechanized, transportable treatment method to address range scrap.

Proposed Solution: This project proposes developing and demonstrating a portable system to safely detonate, shred and deform range scrap such as target items contaminated with UXO, and separate the shredded materials into different types of metals and other inert waste. The shredding process will safely detonate any UXO in the range scrap, rendering it safe for recycling. The recovered metals (primarily iron and aluminum) can be then pressed into 4-ft × 4-ft cubes, which are the industry norm for cost-efficiently transporting and recycling these metals.

Objective: The objective of this project is to develop and demonstrate a portable range scrap processing unit to reduce the cost of range clean-up and to increase worker safety.

Benefits: Segregated metals command a higher recycle value, which will more than offset the cost of the processing equipment. The proposed range scrap processing unit will result in significant cost avoidance to the Navy. In addition, the use of mechanical methods to process contaminated range scrap will reduce worker exposure to potential UXO, increasing worker health and safety.

Project Description Approach: The first step in this project is surveying the market-place and identifying available metal shredding, classification, and crushing equipment. The equipment will be evaluated as to ability to withstand UXO explosions, size of material that can be handled, containment of air emissions, portability, ruggedness, maintainability, capital cost, and operational cost.

The next step is to select the most appropriate equipment and to design an easily trans-portable system using these components and other material handling equipment that can process the waste and produce scrap waste streams that are easily recycled. It is expected that NFESC will team with a contractor who is highly experienced in designing trans-portable units and has experience in handling UXO to develop the most effective system.

Next, a treatment system will be assembled and demonstrated at a range, processing different types of scrap ordnance. Operational and cost information will be gathered and potential enhancements to the system will be identified.

As a final step, a specification for a transportable unit will be finalized and provided for the construction of additional units.

Proposed Funding:

Fiscal Year:	Amount ($K):
2005	270
2006	590
2007	400

Products: The Navy needs a mobile treatment method to address range scrap that is efficient and cost-effective. The final product will be a user data package that describes the specifications for a mobile system that safely detonates, shreds and deforms range scrap (such as target items contaminated with UXO), and separates the shredded materials into different types of metals and other inert waste.

Related Efforts: The Marine Air Ground Task Force Training Command, MCAGCC in Twentynine Palms, CA have been investigating options to systematically address various residue streams and render the processed gleanings available for disposal through recycling. These work processes are presently accomplished at the range residual processing center at MCAGCC Twentynine Palms, CA.

6.3.3 Ecological Soil Screening Levels for Invertebrates and Plants Exposed to Munition Constituents. This project was ranked 39.3 by the RSG and ranked 43.0 by the FAC RAW (#1 of 12). This project is also under consideration for funding due to the high rankings of two functional workgroups.

Problem Statement: The concentrations at which water-borne constituents may be potentially hazardous to aquatic organisms have been identified for numerous materials. The resulting concentrations (including federal criteria and state standards) are frequently used as ecological risk assessment (ERA) screening tools to determine whether or not certain contaminants may pose a risk to ecological receptors. There is an obvious need for similar screening values for soils, and soil screening levels have been generated by various entities, (e.g., New Jersey Department of Environmental Protection, Oak Ridge National Laboratory, Dutch National Institute of Public Health). However, the methods used to develop these screening levels have not been consistent, and are not always acceptable to regulatory bodies. When conducting ERAs, including those at DoD sites, agencies or contractors typically select one or more of these soil screening levels or may use existing literature to establish a separate set of screening values. Such a process is costly, unnecessarily redundant, and does not allow for consistency among sites.

To address the lack of uniformity in the availability of Ecological Soil Screening Levels (Eco-SSLs), the EPA recently organized a Work Group to review literature and publish an interim Eco-SSL guidance document which is available at http://www.epa.gov/ecotox/ecossl/. This site also contains links to the Eco-SSLs that have been completed. The EPA Work Group Eco-SSLs were derived in order to conserve resources by eliminating the need for EPA, state, contractor, and other federal risk assessors to perform repetitious toxicity-data literature searches and toxicity data evaluations for the same contaminants at every site. Eco-SSLs were designed to be protective of receptors that may regularly contact soil or consume organisms that live in or on soil. They are conservative values to be used during the ERA screening process to determine what chemicals pose no ecological risk and can be eliminated from further analysis.

U.S. Navy facilities often include extensive terrestrial areas that contain a variety of contaminants of potential concern. Of special concern are those areas contaminated by munitions and explosive compounds. Therefore, having a tool, such as the Eco-SSLs, available to screen both CERCLA and non-CERCLA sites could accelerate the ERA process and could result in considerable cost and time savings for site cleanup at closed or transferring ranges.

Unfortunately, there are many chemicals for which Eco-SSLs are not available. Many of the chemicals for which data gaps still occur are munitions and explosive compounds. As part of the Eco-SSL Work Group effort, data gaps have been identified and need to be filled in order to provide Eco-SSLs for a number of organic and inorganic compounds, which are needed to support range-related mitigative measures.

Proposed Solution: The objective of this proposed investigation is to develop Eco-SSLs for selected munitions and explosive constituents that may be found on Navy ranges and ordnance contaminated sites. Under this project, data gaps identified by the Eco-SSL Work Group for specific chemicals would be filled to produce soil screening levels for invertebrates and plants. This project will involve the development of Eco-SSLs through the use of laboratory toxicity studies with both plants and animals. The testing protocols used in this project will be derived from those previously identified or developed for

similar projects by the EPA Eco-SSL Work Group. These testing protocols have proven successful in previous projects and have demonstrated strong dose-response relationships (Ecological Planning and Toxicology, Inc., 2000, Kupperman et al., 2002; Phillips et al., 2002; Simini et al., 2002). However, if needed, new testing methodologies will be developed during this project. Regardless of the protocol chosen, the data that are generated would be of the highest quality and would meet the EPA Eco-SSL Work Group DQOs for inclusion as an Eco-SSL. Cooperation and communication with members of the EPA Eco-SSL Work Group will occur throughout this project, to aid in the transition of the results.

This proposed project will result in generation of analytical data for deriving Eco-SSLs for plant and/or invertebrate endpoints for several selected contaminants of concern. The following metals are used in bullets, signaling flares, igniters, tracers, explosives, primers, boosters, detonators, and casings and are data gaps for plants and/or invertebrates: antimony (plant studies), silver (plant and invertebrate studies), barium (plant studies), chromium (VI) (plant and invertebrate studies), and nickel (invertebrate studies). Besides these metals, this project will also evaluate the feasibility of filling data gaps for perchlorate and HMX using plant and invertebrate studies. Alternative "data gap" analytes or a subset of the listed analytes may be included and evaluated if necessary to ensure the most effective use of available resources. In all cases the most bioavailable form (e.g., soluble forms of metals) of the selected analytes will be used. This approach is appropriate for the development of Eco-SSLs because highly bioavailable forms of contaminants are assumed in the completion of a screening level ecological risk assessment, which is the most conservative portion of the ecological risk assessment process.

Objective: The objective of this proposed investigation is to develop the dataset necessary to calculate Eco-SSLs for munitions and explosives-related chemicals often needed to support range-related mitigation measures. Eco-SSLs developed through this project can be used to help the Navy avoid costly and unnecessary remediation based on use of inappropriate ecological endpoints. A secondary objective of this project is to provide the final project deliverables to the EPA Eco-SSL Work Group for eventual inclusion in national guidance documents.

Benefits: The project being proposed under this mini-BAM will complement existing efforts in allowing DoD agencies to conduct a screening level ecological risk assessment at range sites for the full suite of constituents that may be typically found as part of past and/or ongoing range operations.

The primary expected benefits of this program include the following: (a) it will allow the Navy to better assess, in an ecologically-relevant fashion, the potential for adverse effects at sites where soil contamination due to munitions or explosive constituents is of concern; (b) risk managers will be able to use this information to help evaluate and prioritize ordnance-contaminated sites for evaluation in environmental programs; (c) the Navy will potentially avoid costly and unnecessary alteration of habitats based on use of inappropriate ecological endpoints; and (d) the Navy will contribute substantially to the development of a nationally recognized tool for use at other DoD facilities.

Project Description Approach: The following milestones are proposed for the completion of this project; by completing this project in stages, subsequent milestones can be adjusted to meet changing needs of the Navy.

Milestone I – Literature Review. Data gaps in the available Eco-SSLs can be identified to a large degree by examining the existing Eco-SSL documentation. However, research is currently being conducted to produce additional studies that will supplement the existing data. The Phase I review will consist of the tabulation of all known studies that are currently being conducted by researchers to produce Eco-SSLs for the subject compounds. The results of the Phase I work will be tabulated in a simple letter report and will be used to verify the selection of chemicals for evaluation in Phases II and III within the scope of the available resources allocated for the project. Completion of this phase will avoid any duplication of existing efforts, thereby focusing the Navy's funding on chemicals for which Eco-SSLs still must be developed. Depending on the results of this phase of work, alternative "data gap" compounds may be identified for analysis in subsequent phases of work.

Milestone II – Laboratory Toxicity Testing with Plants and Invertebrates. Phytotoxicity tests will be conducted with up to five candidate plant species (e.g., alfalfa, lettuce, radish, barley, etc.), and invertebrate toxicity testing will be conducted using up to three invertebrate species (up to two species of earthworms, springtails, etc). All testing will be conducted using standard ASTM and EPA methods. Toxicity testing will include range-finding tests (five species of plant, three species of invertebrate) and definitive tests (three species of plant, three species of invertebrate), and will be conducted to meet all acceptance and evaluation criteria established by the EPA Eco-SSL Work Group. Species to be tested will be determined after consultation with Navy technical managers and review of existing data. All tests will include sublethal and lethal endpoints. Sublethal endpoints will include at a minimum growth and/or reproduction for invertebrate testing, and germination and/or growth for plant testing. All tests will be conducted using a native soil and an understanding of bioavailability utilizing pH, organic carbon content, and CEC will be completed prior to testing. In addition, all testing will include an aging/weathering procedure prior to test initiation in order to be most representative of conditions at most CERCLA sites (i.e., contaminants may have undergone years of natural weathering).

Milestone III – Data Reporting and Eco-SSL Development. The third phase of work will involve integrating all data obtained in Phases I and II into an Eco-SSL into a concise data report with recommendations for Eco-SSLs for the subject compounds. It is anticipated that development of the Eco-SSL report will involve the EPA Eco-SSL Work Group. The Phase III deliverable could potentially be used for risk assessments of ordnance contaminated sites at Navy facilities throughout North America.

Milestone IV - Presentation of the Eco-SSLs at a Scientific Meeting. Phase IV consists of a presentation of the program at one international or national scientific meeting. In order to communicate this information to other environmental professionals, it is

recommended that provisions be made for presentation of this material in platform or poster format at an international scientific meeting.

Proposed Funding:

Fiscal Year:	Amount ($K):
2005	200
2006	50

Potential Users and Proponents: Any RPMs with munitions or ERCs at terrestrial sites have the potential and need to use the Eco-SSLs. The Risk Assessment Workgroup (RAW) is a strong proponent of this project. The RAW ranked the need for filling data gaps in Eco-SSLs as their number one need for the BAM 05 ranking cycle.

User POCs:

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Milestones:

Milestone	Completion Date Months from Start
Literature Review	2
Laboratory Toxicity Testing with Plants and Invertebrates	9
Data Reporting and Eco-SSL Development	12
Presentation of the Eco-SSLs at a Scientific Meeting	15

Products: The eventual end product of this project would be a documentation report of the data obtained from the testing completed and the development of soil screening levels for the chemicals tested, which can subsequently be used in Navy ERAs.

Transition Plan: Funding of this project will result in generation of high quality data for calculation of Eco-SSLs for a number of the "data gaps" identified by the Eco-SSL Work Group. These data will be available to the Navy, and other Eco-SSL Work Group

members. It is anticipated that transitioning of these data to end-users will be straightforward and that there will be few, if any, institutional or regulatory barriers. The data generated through this program will be of sufficient quality for generation of a peer-reviewed publication.

Related Efforts: Other efforts are currently ongoing to fill other data gaps that were identified by the Eco-SSL Work Group. Data gaps that exist for other military constituents (i.e., RDX and TNT) are being filled by Dr. Roman Lanno (Oklahoma State University) for plants and invertebrates through SERDP project CU-1210. Additional data gaps are being filled through the same project for PAHs and arsenic, which are two other types of contaminants that can be frequently found at DoD cleanup sites. The project being proposed under this mini-BAM will complement existing efforts in allowing DoD agencies to conduct a screening level ecological risk assessment at range sites for the full suite of constituents that may be typically found as part of past and/or ongoing range operations.

6.3.4 Animal Landscape Modeling. This project addresses TES issues and has been initiated at a low level to determine initial feasibility, and to leverage off existing opportunities. The proposed project will be conducted at Camp Lejeune, using the Bachman's sparrow as the primary specie of interest. It is being conducted by Dr. Warren Porter, University of Wisconsin, Madison. The desired outcome is to determine impacts on TES from "normal" living stressors and then with added training impacts that can be quantified (contaminant loads, etc).

6.3.4.1 Introduction. The PI has been developing and testing first principles models of microclimates and animals for more than 20 years. The models has been extended from mammals to terrestrial and now diving birds and puts the microclimate and animal models on a landscape scale. The model has the ability to calculate field metabolic rates and water loss rates that agree extremely well with doubly labeled water measurements of mammals (Arabian oryxes on the Arabian peninsula, diving birds (Great Cormorants in northern and southern Greenland, and reptiles.

These models, their integration with other technologies, and their ability to run on PCs are unique and state-of-the-art. There are no other quantitative first principles models of climate/topography/vegetation/body size interactions with animals on landscapes. The proposed model uses global/regional/local climate data, digital elevation maps, vegetation maps, and animal properties to calculate dynamic interactions of landscape scale available microclimates, animal energetics, behavior, activity patterns, food web structure, aspects of population dynamics and community structure, and potential for air and food-borne pathogen and pesticide exposure.

Application of these models to Bachman's sparrow, *Aimophila aestivalis*, will be straightforward. Bachman's sparrow is one of the very few species of birds that is an endemic to the United States. There is quite a bit of literature data on their life history. These birds are 15 cm in length and weigh approximately 30 g. This is a ground-feeding bird that likes to forage in dense understory vegetation. The breeding season begins in late April, peaks in May, and extends to mid-July. The breeding habitat includes pine woods, especially in areas with dense understory vegetation. The female builds the cup-shaped nest on the ground out of grass and

other plant material. The nest may be domed with grass for protection. The female lays 3-5 eggs that she incubates for 14 days. The young are altricial and fledge 10-11 days after hatching.

6.3.4.2 Goal/Objectives. The objective is to demonstrate the general microclimate-animal modeling capability for computing spatially explicit and temporally varying energetics and behavior of animals, using Bachman's sparrow on the Camp Lejeune landscape. Computations of Bachman's sparrow food and water requirements for survival/maintenance, growth, and reproduction potential assuming that three chicks are fledged each reproductive cycle, and calculate available daily activity hours on a monthly basis for three climate scenarios will be made. A 30-year climate average for each month for the region will be used to drive the calculations. An unusually dry year and an unusually wet year to estimate interannual variance in energetics and activity will be used.

Approach

Task 1 - collect, enter, and verify digital elevation data for Camp Lejeune –one month

Task 2 – collect, enter, and verify vegetation data of Camp Lejeune – one month

Task 3 - obtain bird specimens, measure and enter property data, such as feather length, plumage depth, morphology, solar reflectivity and transmissivity - one month

Task 4 - obtain and enter sparrow physiological properties from the literature such as regulated body temperature, diet, metabolic rates, and water loss rates under laboratory conditions – one month

Task 5 - verify model by doing metabolic chamber simulation calculations to test model calculations against literature data of similarly sized sparrows in metabolic chamber's – one month

Task 6 - do landscape scale climate interpolation based on elevation changes for three climate scenarios: 30 year average, an unusually dry year and an unusually wet year -one month

Task 7 - do landscape scale calculations of bird food and water requirements for average daily maintenance, growth, reproduction (fledging 3 chicks), activity hours available, grams of food needed to meet those requirements, liters of air through the lungs, and moles of CO2 produced for each month of the year using a 30 year climate average, an unusually wet year, and an unusually dry year. - two months

Task 8 - do ArcView GIS graphics for output variables for all three years - two months

Task 9 - analyze data – one month

Task 10 - prepare report - one month

6.3.4.3 Examples Published, In Press, and In Preparation with Collaborators' Test Data

Published Examples. Simulations at 10 m to 0.5° latitude/longitude resolution have shown diverse model applications and predictive capabilities, e.g., changes in animal distributions, impacts of vegetation changes (burns, harvesting) on individual energetics, alteration of food web structure, impacts of low level infections, climate change, topographic/vegetation impacts on activity patterns, and why species clumping or lack of clumping may occur in different communities. The PI has recently applied these models to questions of (1) environmental impacts of controlled forest burns on elk energetics in Yellowstone in winter, (2) the variables controlling the continental distribution of a species of endangered lizard, the chuckwalla, (3) topographic, vegetation, and climate effects on food web structure in time and space for a predator (rattlesnake) and two prey species (diurnal Beechey ground squirrel and nocturnal dusky-footed woodrat) on a real landscape, (4) understanding aspects of why animal body sizes may be clumped on the landscape, (5) calculating the energetic costs of changing environments for the rare and endangered orange-bellied parrot of Australia, (6) understanding paleodistributions and population dynamics of dinosaurs.

In Press Example. The microclimate-ectotherm models have identified key variables controlling the continental distribution of the sexual and parthenogenic races of Binoe's gecko in Australia (Kearney and Porter, 2004). Results were able to quantify racial differences in function by doing 'virtual reciprocal transplants' to evaluate each of the races in their own and other races' distributions. Additionally, significant differences in predictions of the impact of climate warming on distribution changes using a first principles vs. regression approach was found.

6.3.4.4 Examples of Field Tests of the Models. The following examples address a series of questions. How well can climate- animal models based on first principles and using relatively limited generic input data compute vertebrate and invertebrate metabolic rates, water loss rates, food requirements, and activity patterns in the field? How do the results compare with regression approaches to similar estimates? What can regression vs. first principles models say about future climate change scenarios in terms of changes in distribution limits? Can first principles models be used to identify sensitive variables that affect distribution limits? How can satellite data be used to test the models over broad spatial scales?

6.3.4.5 Anticipated Results. GIS type maps of energy expenditure, water requirements, hours available for activity, grams of food required/day for survival/maintenance, growth, and reproduction, liters of air through the respiratory system per day, and moles of CO_2 produced per day will be produced. These maps will appear similar to topographic maps, except that instead of elevation, one of the bird response variables just described will be plotted. These graphs will also be collected into a time series for a year so that a "movie" can be displayed that shows day temporal and spatial variation of requirements for survival, growth, and reproduction across the landscape. These maps can also be surrogates for amount of contaminants ingested or passed through the respiratory system on a daily basis across the landscape.

Graphs will be produced that will allow a comparison of the effects of an unusually dry year versus a 30-year average year. Energy and water requirement differences between a dry

year versus an unusually wet year for all of these response variables will be plotted. For example, differences in metabolic cost across the landscape between an unusually wet year versus an unusually dry year can be calculated and then displayed.

6.4 Technology Gap Survey and Ranking

A web-based form has been designed to allow interested parties rank the proposed new starts as well as the technology gaps identified in Chapter 5. You may log on to the following website for access: http://p2ashore.nfesc.navy.mil/. Both the password and user ID are *rangeidr*. Instructions are provided on-line. The survey allows the user to enter new areas for consideration as well, and space for comments.

Additionally the IDR may be downloaded from this site for review and comment prior to finalizing the document.

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* Additional references not specifically cited in the text of this report

Appendix A

COMPLETE LIST OF GROUPS SUPPORTING THE NAVY'S RANGE SUSTAINABILITY PROGRAM

Range Sustainability IDR POC List

N456:	Karen Foskey (RSEPA)/Geoff Cullison/Wanda Holmes
OPNAV N433K:	Lt. Paul Kesler
NAVFACHQ:	Kelli Ackiewicz
NAVFACHQ:	Frank Peters (RSG)
NAVFACHQ:	Mr. Alan Zusman
ASN:	Doug Zillmer/Paul Yaroschak
LANTDIV:	John Van Name
NOSSA N51:	John Dow
OSD:	Mr. Gregory Schirf
NBVC:	Mr. Tony Parisi (NAVAIR), Martin Ruane
NAS Fallon:	John Smith
NAWC China Lake:	Dr. Kathleen Fallis, Mr. Bud Oldroyd
Twentynine Palms:	Leon Bowling
Camp Lejeune:	Mr. John Townson
MCBH Kaneohe:	Dr. Diane Drigot
PWCNORVA:	Cathy Benoit
ONR:	Dr. Robert Gisiner
CERL:	Dr. Robert Lacey
MCHQ:	Nick Ta/Deborah Morefield/Sherril Gardner
SSC-SD:	Pete Seligman/Bill Wild/Chip Johnson
SERDP/ESTCP:	Mr. Bradley Smith/Dr. Robert Holst/Dr. Jeff Marqusee
LANTFLT:	Hank Eacho
PACFLT:	Larry Foster; Conrad Erkelens
NAVAIR:	Herman Vermall
NAVSEA:	Tim McBride

Table A-1. Groups Supporting the Navy's Range Sustainability IDR

DATE	BASE	LOCATION	COMMENTS/ISSUES PRESENT	ACTION/FUTURE ACTION
01/28/2004	ALLEGANY BALLISTICS LAB	COMNAVSEASYSCOM WASHINGTON DC	Left message with Larry Zajdel, 1/28/04	
12/18/2003	BANGOR NAVSUBASE	CINCPACFLT PEARL HARBOR HI	No issues per Mike Bauers at Ruth Lake	
11/26/2003	BREMERTON NAVSTA	CINCPACFLT PEARL HARBOR HI	No issues per Richard Yale at Naval Ammunition Depot Puget Sound/Burn Slab/Burn Areas	
12/22/2003	BRUNSWICK NAS	CINCLANTFLT NORFOLK VA	No issues per Anthony Williams: W104 Per Earle Folger: Need $$ to comply with permits, problems with storm water run off; need $$ for equipment maintenance; range is in a remote area: encroachment issues (Nside OB/OD Facility)/no general issues present	D Training Area: closed under RCRA; sampling plan will be done;
12/18/2003	CHARLESTON NWS	CINCLANTFLT NORFOLK VA		Future POC: Barry Lewis/(843) 764-4010
	CHINA LAKE NAWC WD	COMNAVAIRSYSCOM PATUXENT RIVER MD		Future needs: nonlead primers, better range ventilation (semi-indoor with better circulation); NEPA: provide for military training
01/15/2004	CORONADO NAVBASE	CINCPACFLT PEARL HARBOR HI	No issues per Scott Penwell	
01/05/2004	CORPUS CHRISTI NAS	CNET	No issues per Beverly Burchard (base not used for security reasons)	
01/06/2004	CRANE NSWC	COMNAVSEASYSCOM WASHINGTON DC	Would recommend faxing questions to 812-854-4177 (James Hunsicker)	
12/18/2003	DAHLGREN CSS NSWC	COMNAVSEASYSCOM WASHINGTON DC	No issues per Carmen Ferrer; 12/18/03	
01/28/2004	DAHLGREN NSWC	COMNAVSEASYSCOM WASHINGTON DC	Left message with Bill Goss, 1/28/04	
01/28/2004	EARLE NWS	CINCLANTFLT NORFOLK VA	Tried calling Gregory Goepfert, 1/28/04, incorrect phone#	
01/05/2004	EL CENTRO NAF	CINCPACFLT PEARL HARBOR HI	No issues per Jim Collins (R2510,2512); however, cleanup/debris needed; better posting of boundaries (near off road recreational areas=possible encroachment issues)	
	D MOBILE UNIT 11	CINCPACFLT PEARL HARBOR HI		
12/01/2003	FALLON NAS	CNO	No issues per John H. Smith	
01/06/2004	INDIAN HEAD NSWC	COMNAVSEASYSCOM WASHINGTON DC	No issues per Elaine Magdinec; 1/6/04	
01/20/2004	INDIAN ISLAND NAVMAG	CINCPACFLT PEARL HARBOR HI	Called Richard Yale on 1/20/04; no answer; left message on 1/28/04	
01/06/2004	JACKSONVILLE NAS	CINCLANTFLT NORFOLK VA	Per Bill Raspet: on land ranges: encroachment, groundwater pollution; Pinecastle: encroachment impact issues	On 1/6/04, Bill Raspet gave us information on environmental issues
01/28/2004	KEY WEST NAS	CINCLANTFLT NORFOLK VA	No answer (Robert Courtright) on 1/5/04,1/27/04; spoke to Bob on 1/28/04: he is sending us a recent range survey	On 1/28/04, Bob Courtright sent us a range survey
01/28/2004	KEYPORT NUWC	COMNAVSEASYSCOM WASHINGTON DC	New POC; No issues per Martin Prehm, 1/28/04	
01/05/2004	KINGS BAY NAVSUBASE	CINCLANTFLT NORFOLK VA	Called 1/5/04; phone # not in service	
01/05/2004	KINGSVILLE NAS	CNET	Called Norma Barrera on 1/5/04; No issues per Norma Barrera, 1/28/04	
01/28/2004	LITTLE CREEK NAVAMPHIBASE	CINCLANTFLT NORFOLK VA	Left message with Brian Hostetler, 1/28/04	
01/27/2004	MARIE ISLAND NSY	COMNAVFACENGCOM WASHINGTON DC	Left message with David Godsy (RPM)/(619) 532-0976, 1/28/04	

Table A-1. Groups Supporting the Navy's Range Sustainability IDR (page 2 of 2)

DATE	BASE	LOCATION	COMMENTS/ISSUES PRESENT	ACTION/FUTURE ACTION	
01/20/2004	MARIANAS NAVFOR	CINCPACFLT PEARL HARBOR HI	Called and spoke with Mike Demenchek, no POC by name of Dale Hoover or C. Prather		
01/28/2004	MERIDIAN NAS	CNET	No answer (Bill Kirby); called on 1/5/04; left message on 1/28/04		
01/28/2004	NEW ORLEANS NAS JRB	COMNAVRESFOR NEW ORLEANS LA	New POC: Stanley Smith/504-678-3096; left message, 1/28/04		
01/06/2004	NEWPORT NUWC	COMNAVSEASYSCOM WASHINGTON DC	Called Elizabeth R. Deblois on 1/6/04; no answer; left message 1/28/04		
01/20/2004	NORTH ISLAND NAS	CINCPACFLT PEARL HARBOR HI	Per Scott Penwell: on land: Endangered Species (San Clemente Sage Sparrow, Night Lizard); on water: marine mammal impact/noise; Eel Point Closed because of Sage Sparrow impacts/fire impacts	Future needs: fire model due to fire impacts on ranges	On 1/20/04, Scott Penwell gave us information on environmental issues
01/20/2004	NORTH ISLAND NAS	CINCPACFLT PEARL HARBOR HI	No issues at Southern California ASW Range/MTR		
01/21/2004	NORTH ISLAND NAS	CINCPACFLT PEARL HARBOR HI	Issues at TAR 17, 10 (old 50 Auto Range): San Clemente Sage Sparrow; fire impact: TAR 10 (old 50 Auto Range); fire impacts	Future needs: fire model due to fire impacts; EIS in process to resolve, etc.	
01/22/2004	NORTH ISLAND NAS	CINCPACFLT PEARL HARBOR HI	Issues at San Clemente Island/SHOBA: Island Night Lizard (on all ranges) due to flatness part of island/ideal for training	Future needs: Surveillance technology (radar); thermal imaging; communication systems	
01/27/2004	OCEANA NAS	CINCLANTFLT NORFOLK VA	Left Message with Joseph A. Vlcek, 1/27/04		
01/07/2004	PATUXENT RIVER NAS	COMNAVAIRSYSCOM PATUXENT RIVER MD	Called Joe Fearns on 1/7/04; no answer		
01/26/2004	PEARL HARBOR FACSFAC	CINCPACFLT PEARL HARBOR HI	No issues per Terence Tengan		
01/27/2004	PEARL HARBOR NAVMAG	CINCPACFLT PEARL HARBOR HI	Left Message with Terence Tengan, 1/27/04		
	PMRF	CINCPACFLT PEARL HARBOR HI	Sent email to Bob Inouye request information; he will forward to POC/Env.		
	POINT MUGU NAS	CINCPACFLT PEARL HARBOR HI			
	POINT MUGU NAWC WD	COMNAVAIRSYSCOM PATUXENT RIVER MD			
01/27/2004	ROOSEVELT ROADS NAVSTA	CINCLANTFLT NORFOLK VA	Called N.I. Delgado and Wilfredo Rivera on 1/27/04; no answer		
	SALTON SEA TEST BASE	COMNAVSEASYSCOM WASHINGTON DC	No issues		
01/27/2004	WHIDBEY NAS	CINCPACFLT PEARL HARBOR HI	Per John Phillips: Issues include noise acoustics (marine mammal issues) at Admiralty Bay (R-6701); Endangered Species issues at NWSTF Boardman (on range itself)		On 1/27/04, John Phillips gave us information on environmental issues
01/27/2004	YORKTOWN NWS	CINCLANTFLT NORFOLK VA	Left Message with Roy Whitman, 1/27/04; see OCEANA also, same POC		

KEY:

**People that could not be contacted; incorrect phone #s.

Appendix B

DRAFT NRO ORGANIZATIONAL STRUCTURE

Navy Ranges & Fleet Training Branch

Working Draft

N433 (O-6)

N433 A

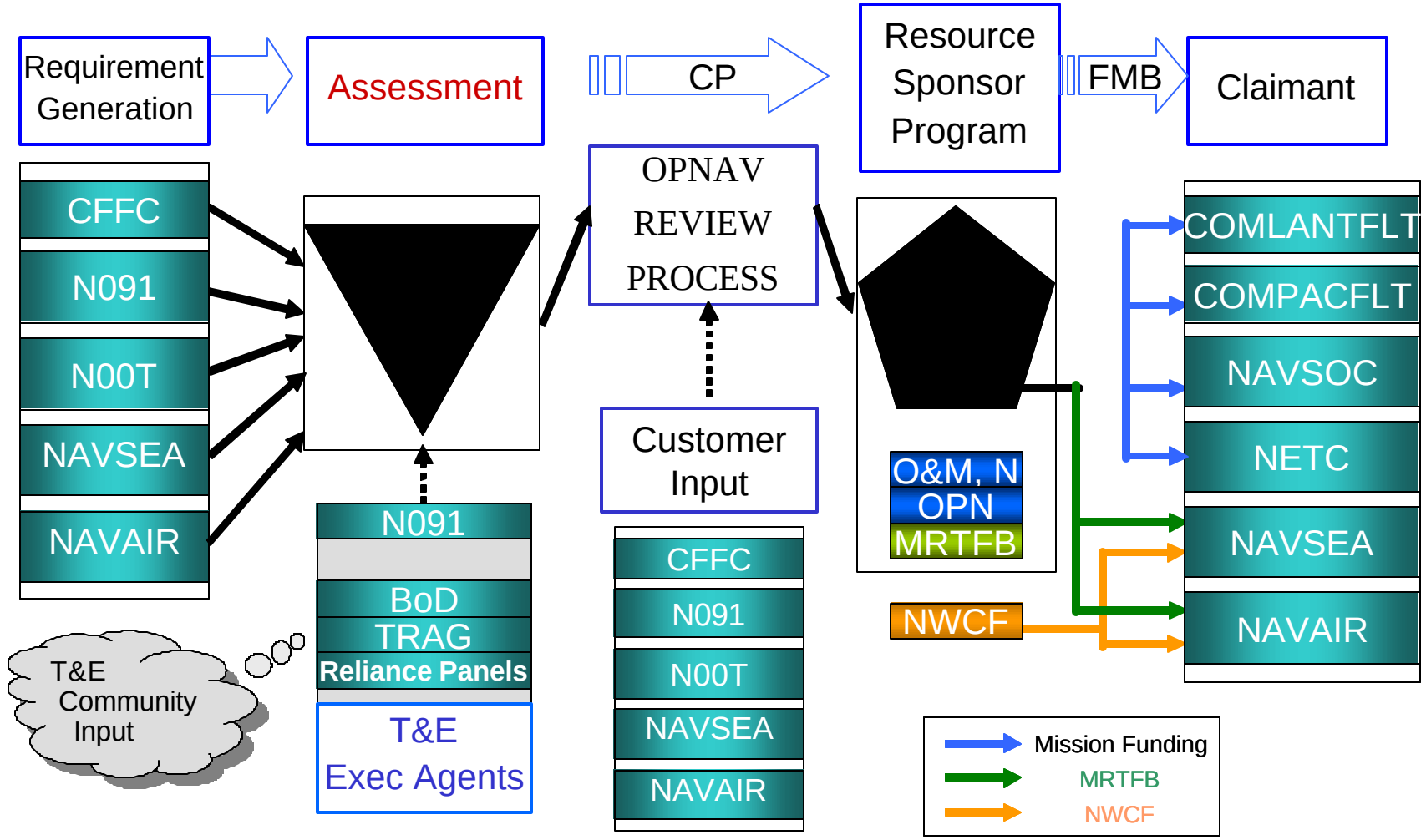
N433B – Deputy Branch Hd, Ranges
N433B1 – Policy and range sustainment
N433B1A/B1B – Range Sustainment Support*
N433B2 – Range Ops & Maintenance
N433B2A – Range O&M,N Analyst
N433B3 – Range Infrastructure
N433B4A – Range Resource Analyst
N433B4B – Range Resource Analyst
N433B4C – Range Resource Analyst
N433B4 – Target Development & Procurement
N433B4A – Target Procurement

N433C– Deputy Branch Hd, Fleet Training
N433C1 – Fleet Training Requirements
N433C2 – Modeling & Simulation Rqmts
N433C3A - Training Analysis Support*
N433C3B – Training Analysis Support*
N433C3C – Training Analysis Support*

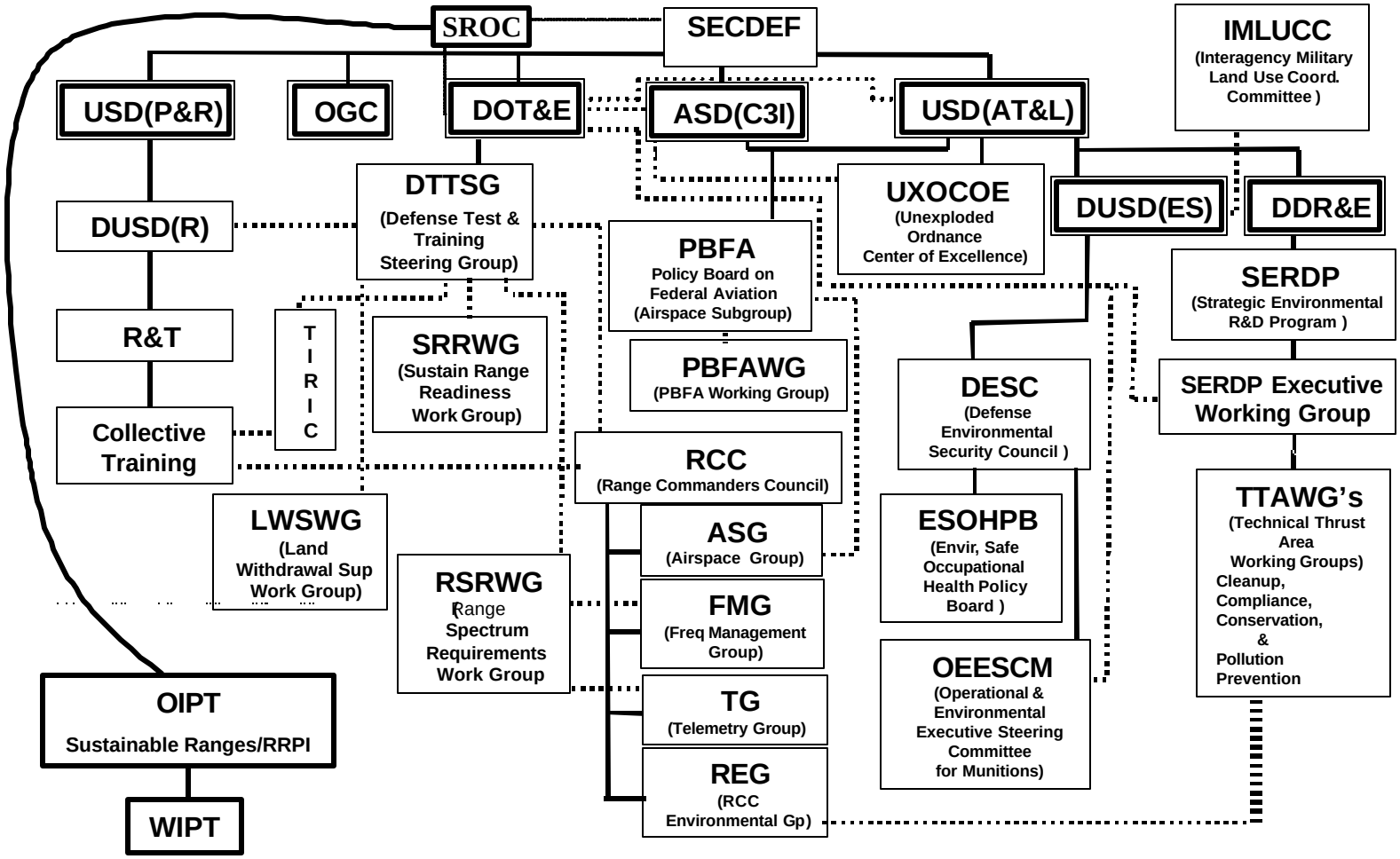
* - Range Sustainment Support additional duty from N45

Ten Personnel full time in Ranges Section

Revised Range PPBE Process

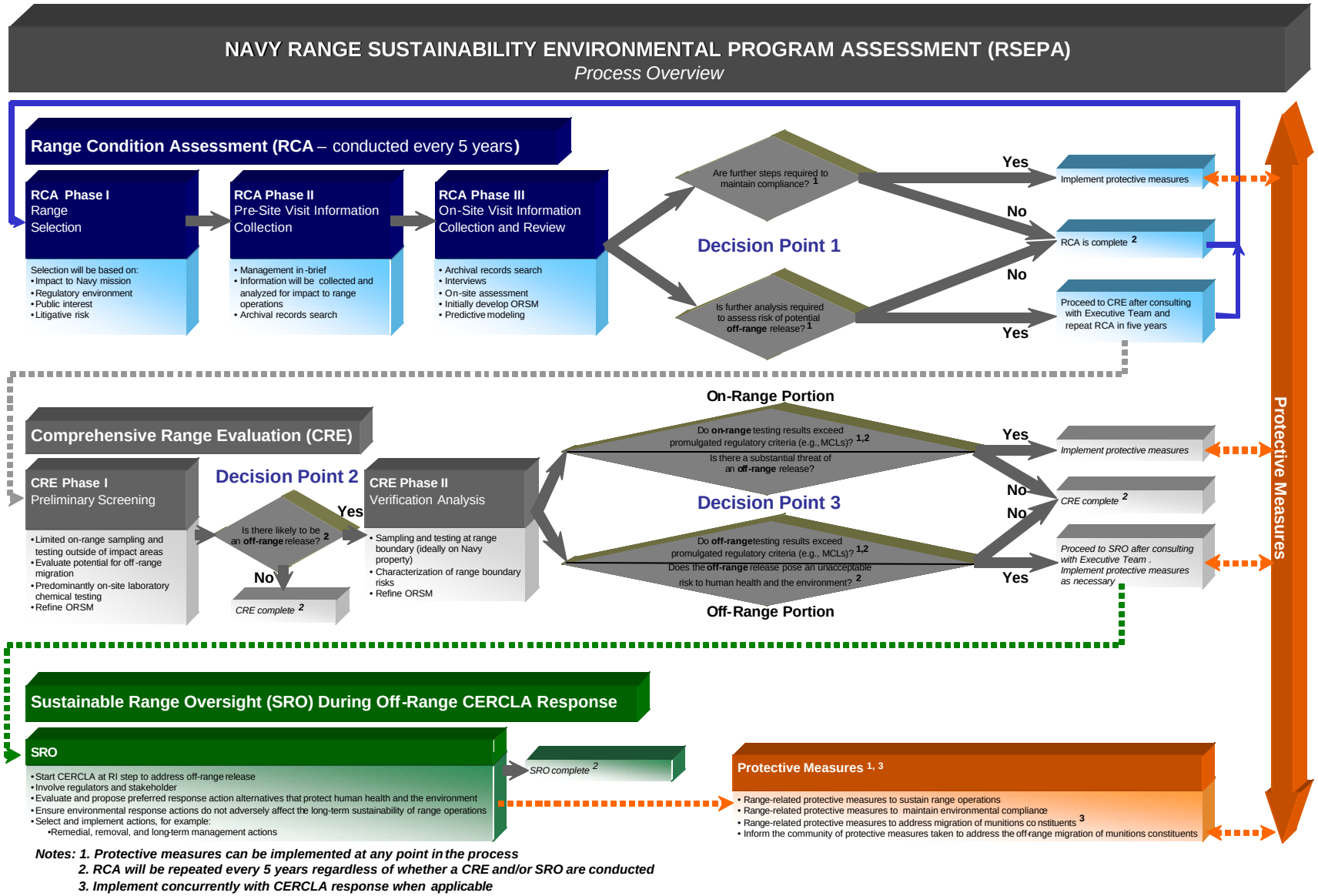


DoD Range Organizations



Appendix C

RSEPA PROCESS OVERVIEW



Notes: 1. Protective measures can be implemented at any point in the process
2. RCA will be repeated every 5 years regardless of whether a CRE and/or SRO are conducted
3. Implement concurrently with CERCLA response when applicable

Appendix D

MASTER LIST OF APPLICABLE LAWS, REGULATIONS, AND OTHER DIRECTIVES

Table D-1. Master List of Applicable Laws, Regulations, and Other Directives[(a)]

LAWS – FEDERAL	Currently Impacts	May Impact in Future	Not Applicable
Abandoned Ship Wreck Act of 1987, PL 100-298 (43 USC 2101-2106)			X
Alternative Motor Fuel Act of 1988, PL 100-494, as amended	X		
American Indian Religious Freedom Act of 1978, PL 95-341, as amended (42 USC 1996-1996a)	X		
Anadromous Fish Conservation Act of 1965, as amended (16 USC 757a-757f)			X
Antiquities Act of 1906, PL 59-209 (16 USC 431-433)	X		
Archalogical and Historic Preservation Act (Moss-Bennett Act) of 1974, PL 86-532 (16 USC 469-469c)	X		
Archalogical Resources Protection Act of 1979, PL 96-95 (16 USC 470aa-470mm)	X		
Atomic Energy Act of 1954, as amended (42 USC 2011 *et seq.*)	X		
Base Closure and Realignment Act (BRAC) of 1988, PL 100-526	X		
Clean Air Act of 1955, 69 Stat. 322, as amended (42 USC 7401-7671q)	X		
Clean Air Act of 1970, as amended (42 USC 7401 *et seq.*)	X		
Clean Water Act of 1977, PL 95-217 (33 USC 1251 *et seq.*)	X		
Coastal Zone Management Act of 1972, PL 92-583 (16 USC 1451-1465)	X		
Community Environmental Response Facilitation Act of 1992, PL 102-426	X		
Comprehensive Environmental Response, Compensation, and Liability (CERCLA) Act of 1980, as amended (42 USC 9601 *et seq.*)	X		
Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 (42 USC 11001 *et seq.)*	X		
Emergency Wetlands Resources Act of 1986, PL 99-645 as amended, (16 USC 3901-3932)	X		
Endangered Species Act of 1973, PL 93-205, as amended (16 USC 1531-1534)	X		
Energy Policy Act of 1992, PL 102-486	X		
Energy Policy and Conservation Act of 1975, as amended (42 USC 6201 *et seq.*)	X		
Erosion Protection Act of 1960, PL 86-645 as amended (33 USC 426-426-3)	X		
Estuary Protection Act of 1968, PL 90-454 (16 USC 1221-1226)	X		
Estuaries and Clean Waters Act of 2000, PL 106-457 (33 USC 2901)	X		
Farmland Protection Policy Act of 1981, PL 97-98, as amended (7 USC 4201-4209)		X	
Federal Cave Resources Protection Act of 1992, PL 100-691, as amended (16 USC 4301-4310)	X		
Federal Facility Compliance Act of 1992, PL 102-386 (42 USC 6901 note, 6908)	X		
Federal Insecticide, Fungicide, and Rodenticide Act of 1947, PL 92-516, as amended (7 USC 136-136y)	X		
Federal Land Policy and Management Act of 1976, PL 94-579, as amended (43 USC 1701-1785)	X		
Federal Noxious Weed Act of 1974, PL 93-629, as amended (7 USC 2801-2814)	X		
Federal Property and Administrative Services Act of 1949 (10 USC 484 *et seq.*)	X		
Federal Tort Claims Act of 1946, as amended (28 USC 2671 *et seq.*)	X		
Fish and Wildlife Conservation Act of 1980, PL 96-366 (16 USC 2901-2912)	X		
Fish and Wildlife Coordination Act of 1934, PL 85-624 (16 USC 661-666c)	X		
Food, Agricultural, Conservation, and Trade Act of 1990 (Pesticide Recordkeeping), PL 101-624, as amended (7 USC 136i-1)	X		
Forest Rangeland Renewable Resource Planning Act of 1974, PL 93-378 (16 USC 1600-1624)	X		
Freedom of Information Act of 1966, as amended (5 USC 552 *et seq.*)	X		
Hazardous and Solid Waste Amendments of 1984, PL 98-616	X		
Hazardous Materials Transportation Act of 1975 (49 USC 5101 *et seq.*)	X		

Table D-1. Master List of Applicable Laws, Regulations, and Other Directives (page 2 of 5)

LAWS – FEDERAL (Continued)	Currently Impacts	May Impact in Future	Not Applicable
Hazardous Materials Transportation Uniform Safety Act of 1990, PL 101-615	X		
Historic Sites, Buildings, and Antiquities Act of 1935, as amended by PL 74-292, PL 100-17 (16 USC 461-467)	X		
Lacey Act of 1900, 31 Stat. 187, as amended (16 USC 701)	X		
Low-Level Radioactive Waste Policy Act of 1980, as amended (42 USC 2021 *et seq.*)	X		
Magnuson-Stevens Fishery Conservation and Management Act of 1976 (16 USC 1801 *et seq.*)	X		
Marine Mammal Protection Act of 1972, PL 92-522, as amended (16 USC 1361-1421h)	X		
Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 USC 1401 *et seq.* and 16 USC 1431 *et seq.*)	X		
Migratory Bird Treaty Act of 1918, 40 Stat 755, as amended (16 USC 703-712)	X		
Military Construction Authorization Act, Passed Annually	X		
Military Construction Codification Act of 1982, PL 97-214	X		
Military Reservation and Facilities: Hunting, Fishing, and Trapping Act of 1958, PL 85-337 (10 USC 2671)	X		
Multiple-Use Sustained Yield Act of 1960, PL 86-517 (16 USC 2671)	X		
National Environmental Policy Act of 1969, PL 91-190 (42 USC 4321-4370d)	X		
National Historic Preservation Act of 1966, PL 89-665, as amended (16 USC 470-470x-6)	X		
Native American Graves Protection and Repatriation of 1990, PL 101-601 (25 USC 3001-3013)	X		
Noise Control Act of 1972 (42 USC 4901 et seq.)	X		
North American Wetlands Conservation Act of 1989, PL 101-233 (16 USC 4401-4414	X		
Noxious Plant Control Act of 1968, PL 90-583 (43 USC 1241 *et seq.)*	X		
Occupational Safety and Health Act of 1970, PL 91-596 (29 USC 651 *et seq.*)	X		
Oil Pollution Act of 1990, PL 101-380 (33 USC 2701 *et seq.*)	X		
Outdoor Recreation -- Federal/State Program Act (16 USC 460 (L) *et seq.*)	X		
Outleasing for Grazing and Agriculture on Military Lands (10 USC 2667)	X		
Plant Quarantine Act of 1912, as amended (7 USC 151 *et seq.*)			X
Pollution Prevention Act of 1990 (42 USC 13101 *et seq.*)	X		
Resource Conservation and Recovery Act of 1976, PL 94-580, as amended (42 USC 6901 *et seq.*)	X		
Rivers and Harbors Appropriations Act of 1899, 30 Stat. 1141, as amended (33 USC 401-403)	X		
Safe Drinking Water Act of 1974, PL 93-523, as amended (42 USC 300f-300j-26)	X		
Sikes Act (Conservation Programs on Military Reservations of 1960), PL 86-797, as amended by Sikes Act Improvement Amendments, PL 93-452 (16 USC 670-670f)	X		
Soil Conservation Act of 1938 (16 USC 5901 *et seq.*)	X		
Soil and Water Resources Conservation Act of 1977, PL 950192, as amended (16 USC 2001-2009)	X		
Solid Waste Disposal Act of 1965, PL 89-272, as amended (42 USC 3251 *et seq.*)	X		
Superfund Amendments and Reauthorization Act (SARA) of 1986, PL 99-499		X	
Taylor Grazing Act of 1934, PL 73-482 (43-USC 315-315o-2)			X
Timber Sales on Military Lands (10 USC 2665)	X		
Toxic Substances Control Act of 1976 (15 USC 2601 *et seq.*)	X		
Used Oil Recycling Act of 1980, PL 96-463, as amended	X		
Water Resources Planning Act, PL 89-80, as amended (42 USC 1962-1962d-20)	X		
Water Quality Act of 1965, PL 89-234	X		
Water Quality Improvement Act of 1970, PL 91-224	X		
Watershed Protection and Flood Prevention Act, PL 92-419 (16 USC 1001-1011, 33 USC 701)	X		
Wild and Scenic Rivers Act of 1968, PL 90-542, as amended (16 USC 1271-1287)		X	

Table D-1. Master List of Applicable Laws, Regulations, and Other Directives (page 3 of 5)

EXECUTIVE ORDERS (E.O.s)	Currently Impacts	May Impact in Future	Not Applicable
E.O. 11514 Protection and Enhancement of Environmental Quality, March 5, 1970 (35 FR 4247), as amended by E.O. 11541 and 119911	X		
E.O. 11593 Protection and Enhancement of the Cultural Environment, May 13, 1971 (36 FR 8921)	X		
E.O. 11644 Use of Off-Road Vehicles on Public Lands, February 8, 1972 (37 FR 2877), as amended by E.O. 12608	X		
E.O. 11988 Floodplain Management, May 24, 1977 (42 FR 26951), as amended by E.O. 12148	X		
E.O. 11990 Protection of Wetlands, May 24, 1977 (42 FR 26961), as amended by E.O. 12608	X		
E.O. 12088 Federal Compliance with Pollution Control Standards, October 13, 1978 (43 FR 47707), revoked in part by E.O. 13148	X		
E.O. 12114 Environmental Effects Abroad of Major Federal Actions, January 4, 1979 (44 FR 1957)	X		
E.O. 12843 Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances, April 21, 1993 (58 FR 21881)	X		
E.O. 12856 Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, August 3, 1993 (58 FR 41981)	X		
E.O. 12873 Federal Acquisition, Recycling, and Waste Prevention, October 20, 1993 (53 FR 54911)	X		
E.O. 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations, February 11, 1994 (59 FR 7629)	X		
E.O. 12906 Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure, April 11, 1994 (59 CFR 17671)	X		
E.O. 12962 Recreational Fisheries, June 7, 1995 (60 FR 30769)	X		
E.O. 13007 Indian Sacred Sites, May 24, 1996 (61 FR 26771)	X		
E.O. 13045 Protection of Children from Environmental Health Risks and Safety Risks, April 21, 1997 (62 FR 19885)	X		
E.O. 13089 Coral Reef Protection, June 11, 1998 (63 FR 32701)	X		
E.O. 13112 Invasive Species, February 3, 1999 (64 FR 6183)	X		
E.O. 13123 Greening the Government through Efficient Energy Management, June 8, 1999 (64 FR 30851)	X		
E.O. 13134 Developing and Promoting Bio-Based Products and Bioenergy, August 16, 1999 (64 FR 44639)		X	
E.O. 13148 Greening the Government through Leadership in Environmental Management, April 21, 2000 (65 FR 24595)	X		
E.O. 13158 Marine Protected Areas, May 26, 2000 (65 FR 34909)	X		
E.O. 13186 Responsibilities of Federal Agencies to Protect Migratory Birds, January 10, 2001 (66 FR 3853)	X		
Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds, April 26, 1994 (60 FR 40837)	X		
Memorandum on Environmentally Beneficial Landscaping: Environmentally and Economically Beneficial Practices on Federal Landscaped Grounds, April 26, 1994	X		
Memorandum of Understanding between the Department of Defense and the U.S. Fish and Wildlife Service for the Ecosystem-Based Management of Fish, Wildlife, and Plant Resources on Military Lands, May 1999	X		
Memorandum of Understanding to Foster the Ecosystem Approach, December 15, 1995	X		

Table D-1. Master List of Applicable Laws, Regulations, and Other Directives (page 4 of 5)

NONMILITARY NOTICES, POLICIES AND REGULATIONS	Currently Impacts	May Impact in Future	Not Applicable
Code of Environmental Management Principles for Federal Agencies (61 FR 54062)	X		
Curation of Federally Owned and Administered Archeological Collections (36 CFR 79)	X		
Determination of Eligibility for Inclusion in the National Register of Historic Places (36 CFR 63)	X		
Environmental Protection and Enhancement: Subpart H Historic Preservation (32 CFR 650)			X
Federal Wildland Fire Management Policy (1995)	X		
Final Notice of Issuance and Modification of Nationwide Permits, March 9, 2000 (65 FR 12818)	X		
Fish and Wildlife Service List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12)	X		
Historic Preservation Certificates (36 CFR 67)	X		
Hunting and Fishing Permits (32 CFR 552.19)	X		
National Historic Landmarks Program (36 CFR 65)	X		
National Register of Historic Places (36 CFR 60)	X		
Native American Graves Protection and Repatriation Act Regulations (43 CFR 10)	X		
Preservation of American Antiquities (Antiquities Act regulations) (43 CFR 3)	X		
Protection of Historic and Cultural Resources (36 CFR 800)	X		
Regulations for Implementing NEPA (Council on Environmental Quality) (40 CFR 1500)	X		
The Secretary of Interior's Standards for Historic Preservation Projects (36 CFR 68)	X		
Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, Notice of Final Policy, October 18, 2000 (65 FR 62566)	X		
Waiver of Federal Agency Responsibility under Section 110 of the National Historic Preservation Act (36 CFR 78)	X		

Table D-1. Master List of Applicable Laws, Regulations, and Other Directives (page 5 of 5)

MILITARY DIRECTIVES, ORDERS, INSTRUCTIONS, MEMORANDUMS, POLICIES, AND NOTICES	Currently Impacts	May Impact in Future	Not Applicable
"Agreements to Limit Encroachment and Other Environmental Constraints on Navy and Marine Corps Installations" Assistant Secretary of the Navy (Installations and Environment) Memorandum of 23 Jan 2003	X		
Acquisition, Use By Others and Disposal of Department of the Navy Real Property SECNAVINST 11011.47		X	
Air Installations Compatible Use Zones (AICUZ) Program OPNAVINST 11010.36B		X	
Archalogical and Historic Resources Management (Department of Defense Directive) DoDD 4710.1 (June 21, 1984)	X		
Encroachment Control, MCO 11011.22A (November 25, 1987)	X		
Environmental and Explosive Safety Management on Department of Defense Active and Inactive Ranges Outside the United States, DoD Directive 4715.12 (August 17, 1999)	X		
Environmental and Explosive Safety Management on Department of Defense Active and Inactive Ranges Within the United States, DoD Directive 4715.11 (August 19, 1999)	X		
Environmental and Natural Resources Program Manual OPNAVINST 5090.1B (October 17, 2002)	X		
Environmental Compliance and Protection Manual, Marine Corps Order (MCO) P5090.2A	X		
Environmental Conservation Program (Department of Defense Instruction) DoDI 4715.3 (May 3, 1996)	X		
Environmental Compliance (Department of Defense Instruction) DoDI 4715.5 (April 24, 1996)	X		
Environmental and Explosive Safety Management of DoD Active and Inactive Ranges Within and Outside of the United States DoD 4715.11 and 4715.12	X		
Environmental Planning and Analysis (Department of Defense Instruction) DoDI 4715.9	X		
Military Munitions Rule (MMR), 62 FR 6621	X		
Navy "At Sea" Policy -- UASN Robert Pirie Memorandum (December 28, 2000) Compliance with Environmental Requirements in the Conduct of Naval Exercises or Training at Sea.	X		
U.S. Navy Range Clearance Policy (CNO N45 Draft) OPNAVINST 3550.XX		X	
U.S. Navy Range Sustainability Environmental Program Assessment (RSEPA) Policy Implementation Manual	X		
Use of Ecological Risk Assessments (Department of the Navy Environmental Policy Memorandum 97-04 (CMC Ltr 5090 LFL/KK-140 of March 23, 1997))	X		

(a) Table summarizes the majority of federal laws, E.O.s, regulations as well as other directives and instructions and their expected influence on Range Sustainability as set forth in this document.

Appendix E

GLOSSARY

Active Munitions Inventory (or Stockpile): The supply of chemical and conventional military munitions that are available for issue and use for combat, training, demonstrations, or research, development, testing, or evaluation. (See Munitions Stockpile and Demilitarization Inventory)

Active Range (40 CFR §266.201)**:** A military range that is currently in operation, construction, maintenance, renovation, or reconfiguration to meet current DoD component training requirements and is being regularly used for range activities.

Closed Range: (Proposed Range Rule, 62 *Federal Register* 50,834 [1997]): A military range that the military has either taken out of service as a range and has either been put to new uses that are incompatible with range activities or the military no longer considers to be a potential range area. A closed range is still under the control of a DoD component.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): This law authorized federal action to respond to the release or substantial threat of release into the environment of hazardous substances, pollutants, or contaminants that may present an imminent and substantial danger to public health or welfare.

Danger Zone: A defined water area established by the U.S. Army Corps of Engineers (USACE) and codified in CFR Title 33 for the Armed Forces' purposes of target practice, bombing, rocket firing, or other especially hazardous operations.

Data Quality Objectives (DQOs): DQOs are statements that define the type, quality, and quantity of data required to answer specific environmental questions and support environmental decision-making for RSEPA.

Demilitarization ('Demil'): Demilitarization is a process that removes the military characteristics from unused munitions that are either unsuitable for continued storage, excess to DoD needs or before they are released from DoD control. Demilitarization applies equally to munitions in unserviceable or serviceable condition. Used (i.e., fired) munitions items also sometimes undergo demilitarization. There are many demilitarization methods such as recovery, recycling, remanufacture, disassembly, reclamation, mutilation, alteration, melting, burning, detonating, destruction, treatment and disposal.

Demilitarization ("Demil") Inventory: The demilitarization inventory consists of excess, obsolete and unserviceable munitions. Munitions are moved from the active inventory to the demilitarization inventory after a determination has been made that they are either not economically repairable, obsolete, or excess to the DoD's needs and cannot be sold under the Foreign Military Sales program. (Also see Active Munitions Inventory and Munitions Stockpile.)

Department of Defense Components: The Office of the Secretary of Defense, the Military Departments and Services, the Joint Staff, the Unified and Specified Combatant Commands, the Defense Agencies, the DoD Field Activities, and the National Guard.

Department of Defense Explosives Safety Board (DDESB): A Joint Service board composed of a chairperson, voting representatives from each of the Services, and a permanent military and civilian Secretariat, to perform Board operational and administrative functions. The DDESB provides impartial and objective advice to the Secretary of Defense and DoD Components on explosives safety matters. (See DoD 6055.9-STD for a detailed assignment of Board functions.)

Discarded Military Munitions (DDM): Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations (10 USC 2710 (e)(2)). (From Office of the Under Secretary of Defense Memorandum, Dec. 18, 2003.)

Encroachment: Broadly defined as all external pressures or influences affecting ranges and supporting installations that inhibit accomplishment of test and training as required, including, but not limited to, endangered species and critical habitat, UXO and munitions, frequency spectrum, maritime, airspace restrictions, air quality, airborne noise, and urban growth issues.

Energetic Material: A component of, or an item of ammunition that is designed to produce the necessary energy required for ignition, propulsion, detonation, fire or smoke, thus enabling the item to function. Also a material (corrosive, oxidizer, etc.) that is inherently dangerous and capable of causing serious damage and which requires regulated handling to avoid accidents in connection with its existence and use.

Explosive Ordnance Disposal (EOD) Personnel: Military members who have graduated from the Naval School, Explosive Ordnance Disposal. They have received highly specialized training to provide time-critical UXO hazard mitigation services during both peacetime and wartime. D personnel are trained and equipped to perform Render Safe Procedures (RSP) on nuclear, biological, chemical, conventional, and improvised explosive devices. (Note that D personnel are distinguished from UXO Technicians who are civilian contractor or government personnel with specialized training and qualifications in the long-term remediation of UXO.)

Free from Explosive Hazard: Material that has been inspected for explosives and determined not to present a danger of explosion or combustion from explosive or energetic materiel.

Hazardous Waste: A solid waste is a hazardous waste if it: (1) is, or contains, a hazardous waste listed in the Code of Federal Regulations (CFR) at 40 CFR Part 261 Subpart D, or (2) exhibits characteristics of ignitability, corrosivity, reactivity, and/or toxicity. (Refer to 40 CFR § 261.3 for further explanation.)

Impact Area: The identified area within a range intended to capture or contain ammunition, munitions, or explosives and resulting debris, fragments, and components from various weapon

system employments. In simple terms, normally the target area where live-fire rounds or bombs impact the earth.

Inactive Range (40 CFR §266.201)**:** A military range that is not currently being used, but that is still under military control, and which the military both considers to be a potential range area and has not put to a new use that is incompatible with range activities. A potential range area is defined as meeting one of three criteria: These are: (1) (Mobilization and Force Projection) Ranges that are held by a DoD component for the purpose of preparing individuals and units for worldwide deployment, redeployments, or demobilization in response to war, stability, and support operations or projected training requirements that would exceed current active range capabilities; (2) (Force Structure) Ranges held as inactive during realignment, reorganization, stationing, or re-equipping of units projected to use these ranges under new training requirements; or (3) (Future) Ranges that are held by DoD components for future use in support of the National Security Policy or DoD component doctrine that ensures the capability to produce, establish, and maintain conditions needed for operational success.

Inert Ammunition or Munitions: Ammunition and components that contain no explosive material. Practice bombs containing marking or smoke cartridges do not meet this definition.

Integrated Training Area Management (ITAM): An Army program designed to improve range conditions by inventorying and monitoring land conditions; determining carrying capacity of the land in terms of the training requirements; and providing for land rehabilitation and maintenance measures.

Marker Compounds: Sampling and field-testing for the CRE Phase 1 will focus on hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), and 2,4,6-trinitrotoluene (TNT) since studies have shown that RDX, HMX, and TNT are detected in a high percentage of samples containing MCs. Appendix D summarizes this information and lists specific references supporting this approach.

Material that Presents a Potential Explosive Hazard (MPPEH): Military munitions, to include their components; munitions packaging material; residues from RDT&E, production, use (to include range scrap), operational and quality testing, or demilitarization of munitions; or any other materials, equipment, or facilities potentially contaminated with explosives. Both end items and residues derived from processing end-items within United Nations Organization (UNO) Hazard Class (HC). Munitions-related items, pieces, models, training aids, etc., that are suspected, but not confirmed, to be wholly inert.

Military Munitions (40 CFR §260.10)**:** All ammunition products and components produced or used by or for DoD or the U.S. Armed Services for national defense and security, including military munitions under the control of DoD, the U.S. Coast Guard, DOE, and National Guard personnel. The term includes: confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries used by DoD components, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition

charges, and devices and components thereof. Does not include wholly inert items, improvised explosive devices, and nuclear weapons, devices, and components thereof. (However, it does include nonnuclear components of nuclear devices, managed under DOE's nuclear weapons program after all required sanitization operations under the Atomic Energy Act of 1954, as amended, have been completed.)

Military Range (40 CFR §266.201)**:** A designated land or water area set aside, managed, and used to conduct research on, develop, test and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. This definition does not include airspace, or water, or land areas underlying airspace used for training, testing, or research and development where military munitions have not been used.

Munitions and Explosives of Concern (MEC): This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means:

(A) Unexploded Ordnance (UXO), as defined in 10 USC 2710(e)(9)
(B) Discarded military munitions (DMM), as defined in 10 USC 2710 (e)(2);
or
(C) MCs (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard.
(From Office of the Under Secretary of Defense Memorandum, Dec. 18, 2003.)

Munitions Constituents (MC): Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions (10 USC 2710(e)(4)) (from Office of the Under Secretary of Defense Memorandum, Dec. 18, 2003.)

Munitions Constituents (MC): Materials originating from military munitions, including explosive and nonexplosive materials, and the emissions, degradation, or breakdown products of such munitions, including 1,3-dinitrobenzene, 2,4- dinitrotoluene (DNT), 2,6-DNT, hexahydro 1,3,5-trinitro-1,3,5-triazine (RDX), nitrobenzene, nitroglycerin, 2-nitrotoluene, 3-nitrotoluene, 4-nitrotoluene, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), perchlorate, 1,3,5-TNB, 2,4,6-trinitrotoluene (TNT), methyl-2,4,6-trinitrophenylnitramine, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotoluene (from RSEPA Manual, CNO, Dec. 2003).

Munitions Response Program (MRP): The Munitions Response Program (MRP) addresses munitions of explosive concern (MEC) and munitions constituents (MC) on other than operational ranges and defense sites. The program includes: closed ranges where the military retains the property; transferred ranges where the military has already excessed the property, such as FUDS or a non-BRAC transfer; transferring ranges which are primarily in the BRAC category; and other defense sites, which can include disposal sites, and nonpermitted OB/OD sites not located on operational ranges. At other than operational ranges responses or "cleanup actions"

are conducted to protect human health and the environment and to support reasonable anticipated reuse. These cleanup actions cleanup actions are primarily governed by CERCLA.

Munitions Rule Implementation Policy: Detailed guidance and procedures issued by the Services that explains how DoD will implement and comply with the EPA Military Munitions Rule (MMR).

Munitions Stockpile: The Stockpile includes munitions in the active and demilitarization inventories as well as unused waste munitions as defined in the Environmental Protection Agency's (EPA) MMR. (See Active Munitions Inventory and Demilitarization Inventory)

National Environmental Policy Act (NEPA): This law provides a basic national charter for the protection of the environment. It establishes policy, sets goals, and provides a means for carrying out environmental policy. Environmental Assessments (EAs), Environmental Impact Statements (EISs), and Findings of no Significant Impact (FONSI) are all NEPA documents.

Open Burn (OB) (40 CFR §260.10)**:** Open burning means the combustion of any material without control of combustion air to maintain adequate temperature for efficient combustion, containment of the combustion-reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion, and control of emission of the gaseous combustion products. Most OB sites are permitted as miscellaneous units as part of the EPA permitting process for Treatment, Storage, and Disposal Facilities (TSDFs).

Open Detonation (OD): A chemical process used for the treatment of unserviceable, obsolete, and or waste munitions whereby an explosive donor charge initiates the munitions to be detonated. Although surface detonations can be performed under certain circumstances, most munitions are treated in 4- to 6-foot-deep pits for safety purposes. Most OD sites are permitted as miscellaneous units as part of the EPA permitting process for TSDFs. DoD's units are generally permitted as combined OB/OD facilities.

Operating Area (OPAREA): Land, airspace, sea space, or undersea space used by military personnel or equipment for military testing and training that are not part of a range. Operating areas are typically used to maneuver equipment to appropriate range areas. Examples could include aircraft ingress and egress areas, missile flight areas, riverine training areas, and amphibious landing areas.

Operational Range: A military range that is used for range activities, or a military range that is not currently being used, but that is still considered by the Secretary of Defense or the Secretary of a Military Department to be a range, is under the jurisdiction, custody, or control of the DoD, and has not been put to a new use that is incompatible with range activities. Also includes OPAREAs, and active and inactive ranges that are defined by 40 CFR 266 Range.

Operational Range Site Model (ORSM): An ORSM is a description of a particular site and its environment that is based on existing knowledge. It describes potential sources of MCs and other potentially hazardous substances, transport pathways and mechanisms, and routes of exposure to off-range receptors. It assists the Technical and Management Teams in their

planning, data interpretation, and communication. It is an iterative description that changes over time as more information becomes available.

Predictive Modeling: Analytical tools used to estimate concentrations in various environmental media to determine if the potential exists for an off-range release of MCs and degradants. Potential concentrations of munitions constituents are estimated using mass-loading principles (e.g., munitions usage data, dud and low-order detonation rates, assumptions about targets). Multimedia pathway modeling is used to predict the potential vertical and horizontal migration of munitions constituents off range through various environmental media. Munitions constituents to be modeled include 2,4-DNT, HMX, RDX, TNT, and perchlorate. The modeling shall produce ranges of concentrations (i.e., from conservative to realistic) for later comparison to risk-based criteria.

Range: A designated land and water area set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. The definition of a range does not include airspace, water, or land areas underlying airspace used for training, testing, or research and development where military munitions have not been used (DoD Directive 4715).

Range Boundary: Possible factors to help define range boundaries are boundaries set forth in Fleet Area Control and Surveillance Facility (FACSFAC) instructions; impact areas, as defined by geographically specific features (e.g., shorelines, groundwater levels, steep cliffs, radius from target); range air installation compatible use zones (RAICUZ); real estate boundaries (e.g., lease of deed, land withdrawals); regulatory agreements; security fence lines; and surface danger zones established in the CFR.

Range Complex: Multiple ranges and operational areas (OPAREAs) that comprise a single operational and training entity. Note: For the purposes of this manual, the term "ranges," specifically refers to those land-based assets that lie within range complexes.

Examples of Land-Based Components of Operational Ranges:

- For on-shore firing points where munitions are fired or launched into the water, the RSEPA process will evaluate the firing point and other land-based components only.
- For munitions fired from ship to shore, the RSEPA process will evaluate the impact area and other land-based components only.

Range and Operating Area (OPAREA): Specifically bounded geographic areas that may encompass a landmass, body of water (above or below the surface), and/or airspace used to conduct operations, training, research and development, and test and evaluation of military hardware, personnel, tactics, munitions, explosives, or electronic combat systems. Those areas shall be under strict control of the Armed Forces or may be shared by multiple agencies.

Range Clearance: An operation or procedure conducted to remove and properly dispose of munitions or munitions fragments. (e.g., UXO - "duds," etc.). Several types or degrees of

clearance may be conducted (e.g., surface clearance based on visual inspection of the surface; shallow clearance where an area is systematically swept with detectors—normally to a depth of 20-24 inches; etc.). Range clearance, though technically applicable to any range category (i.e., closed, transferred, active, etc.) is often considered as occurring only at *active, operational ranges*. Clearance operations at these active ranges are normally conducted as part of range maintenance activities to maintain or enhance operational safety conditions at the range facility. Even though it is possible for munitions/UXO to cause environmental contamination (i.e., pollution of soil, surface water, groundwater, etc., from the chemical constituents present in munitions), range clearance is focused on removing and safely disposing of munitions/ordnance items or fragments—*not* the removal or treatment of any chemical residues or constituents from the munitions or associated environmental contamination. Cleanup of environmental contamination or pollution is normally achieved by **Removal or Remedial Actions**.

Range Data Folder (RDF): An RDF is created for each range going through RSEPA for use by the applicable CFFC, Systems Command/Claimant, and Installation. Each RDF will include results, outcomes, and recommendations identified during each phase of RSEPA. RDFs may be used to assist installations in developing range management plans or to enhance or broaden existing plans.

Range Encroachment: External influences threatening or constraining range and OPAERA activities required for force readiness and weapons RDT&E. It includes, but limited to, endangered species and critical habitat, unexploded ordnance and munitions, electronic frequency spectrum, maritime, airspace restrictions, air quality, airborne noise, and urban growth.

Release: Munitions or munitions constituents (MCs) that escape into the environment beyond the defined range boundary.

Resource Conservation and Recovery Act (RCRA): This act regulates the management of solid and hazardous wastes. Specifically, the RCRA requires cradle-to-grave management of all hazardous wastes.

Small-Arms Ranges: A designated land or water area utilized for training or recreational use of small arms weapons, excluding high explosive filled/loaded projectiles), including pistols, rifles, shotguns, and machine guns. This definition includes skeet/trap ranges.

Small-Arms Ammunition: Ammunition for small arms (i.e., all ammunition up to and including .50 caliber). U.S. Army Corps of Engineers Engineering Pamphlet (EP) 75-1-2, *Unexploded Ordnance (UXO) Support During Hazardous, Toxic, and Radioactive Waste (HTRW) and Construction Activities*.

Sustainable Use: Actions taken to ensure ranges maintain the ability to conduct training, research, development, testing, and evaluation of munitions in support of the national defense mission while minimizing adverse effects to human health and the environment.
Sustainable Ranges: Ranges that are managed and operated to support their long-term viability and utility to meet the National defense mission.

Transferred Range (Proposed Range Rule, 62 *Federal Register* 50,834 [1997])**:** A military range that is no longer under the control of a DoD component and has been leased, transferred, or returned to another entity, to include federal entities, for use.

Transferring Range (Proposed Range Rule, 62 *Federal Register* 50,834 [1997])**:** A military range that is proposed to be leased or transferred from DoD to another entity or disposed of by conveying title to a nonfederal entity. An active range will not be considered a "transferring range" until the transfer is imminent.

Unexploded Ordnance (UXO): (40 CFR §266.201) Military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and that have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or materiel and remains unexploded either by malfunction, design, or any other cause. UXO presents an immediate risk of acute physical injury from fire or explosion resulting from accidental or unintentional detonation.

Used or Fired Military Munitions: Used or fired munitions are those military munitions that: (1) have been primed, fuzed, armed, or otherwise prepared for use, and that have been fired, dropped, launched, projected, placed, or otherwise used; (2) munitions fragments, (e.g., shrapnel, casings, fins, and other components, to include arming wires and pins) that result from the use of military munitions; or (3) malfunctions or misfires (e.g., fail to properly fire or detonate).

Waste Military Munition (WMM): A military munition is a "waste" military munition if it has been identified as (1) a solid waste per 40 CFR Subpart M sections §266.202 or (2) a hazardous waste per 40 CFR Part 261 Subpart C or D. In general, WMMs are hazardous waste when they exhibit the hazardous waste characteristic of ignitability, corrosivity, reactivity, or toxicity, or are listed as a hazardous waste.

Water Range: A designated water or water/land area set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. This definition does not include water or land areas underlying airspace used for training, testing, or research and development where military munitions have not been used. Only land-based portions (e.g., firing points, impact areas) of water ranges will be included in RSEPA.

Wholly Inert: Those munitions or munitions components that have never contained reactive materials (e.g., dummy munitions). Once an item is employed as a component of a military munition, it is no longer considered wholly inert.